AUTOMATION

DECEMBER 1954
A PENTON PUBLICATION
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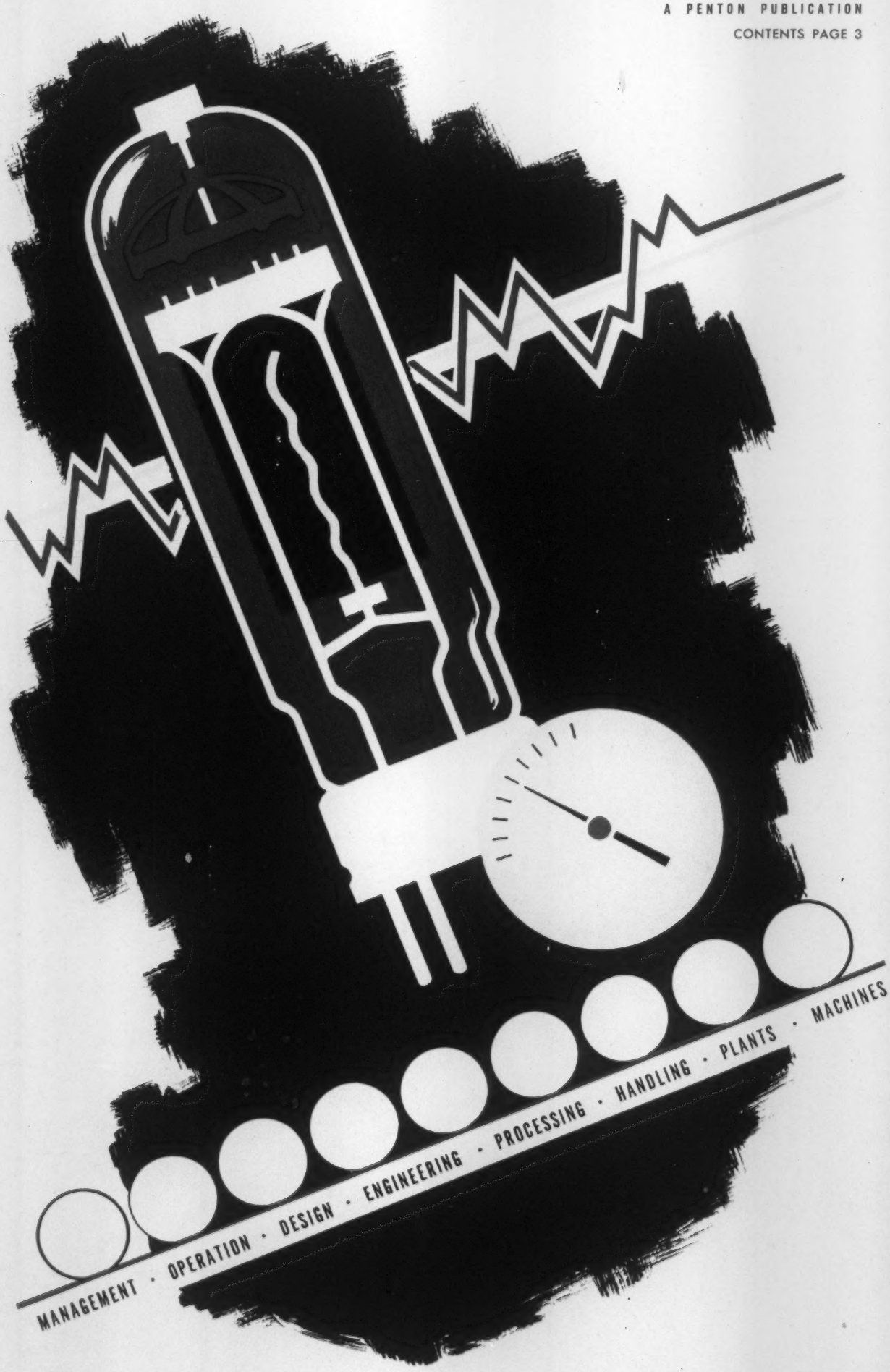


WEAN "AUTOMATED" TRANS-CAR LINE SOLVES HEAVY PARTS HANDLING PROBLEM

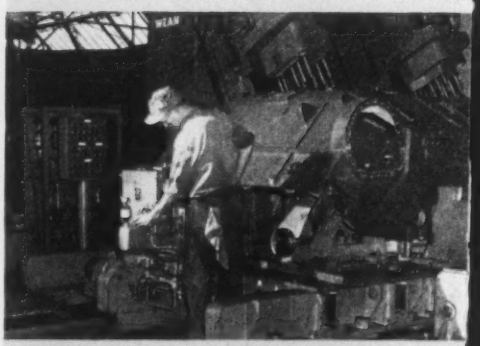
Unique system carries bulky sections through entire machining operation

The Massey-Harris Co. is used to handling and precision working large machine components. Thus, when they accepted the contract to produce combat vehicle hulls for the Army they immediately got in touch with Wean Equipment engineers.

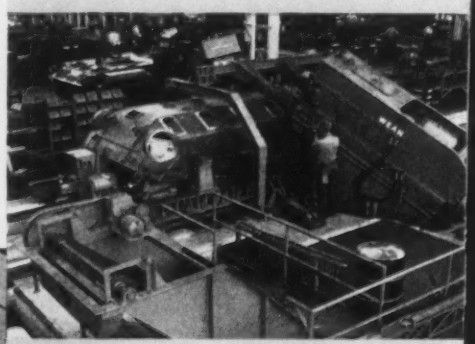
A team of Wean Equipment engineers working with a similar group from Massey-Harris soon vetoed the possibility of using standard machine tools on a cost basis. It was decided a complete line, especially built to do the job, was the only practical answer.

In eight months' time, Wean Equipment developed and built the now famous trans-car line. The line is composed of three stations: milling, drilling, and boring. The unusual feature is the car that operates on a set of tracks, running between stations, and eliminates all handling of the bulky, heavy hull.

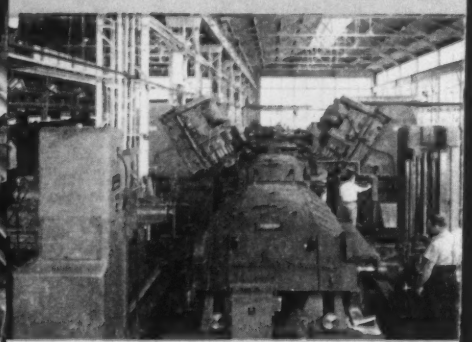
If special "automated" machinery is what you're looking for, call in a Wean Equipment man today. He represents probably the widest experience in specialized machinery to be found anywhere. Like Massey-Harris, you'll find Wean the surest, most inexpensive way to soundly engineered, result-getting machinery.



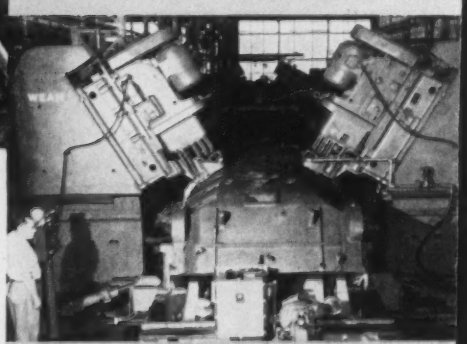
Unique trans-car that carries hull from station to station.



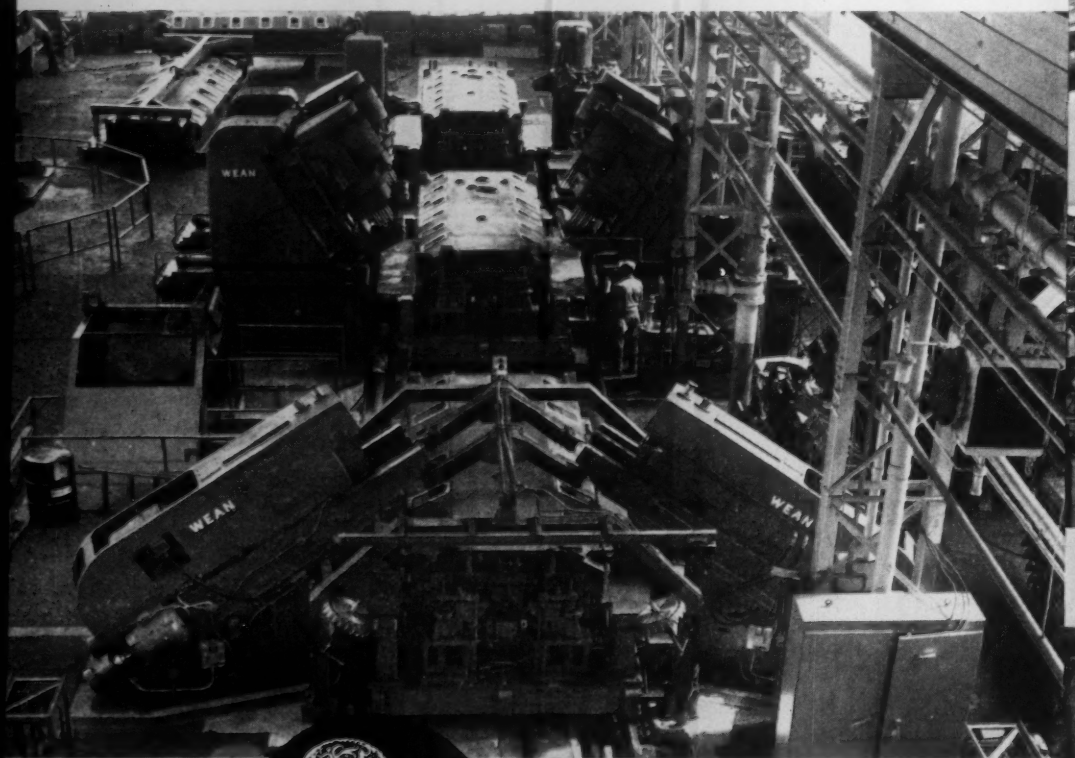
Milling operation. Dry cutting with carbide cutters. Air jets remove chips.



Drilling operation. Beneath the floor a coolant system with magnetic chip separator.



Boring operation. Drills, taps and reamers are of high speed steel. All operations are automatic.

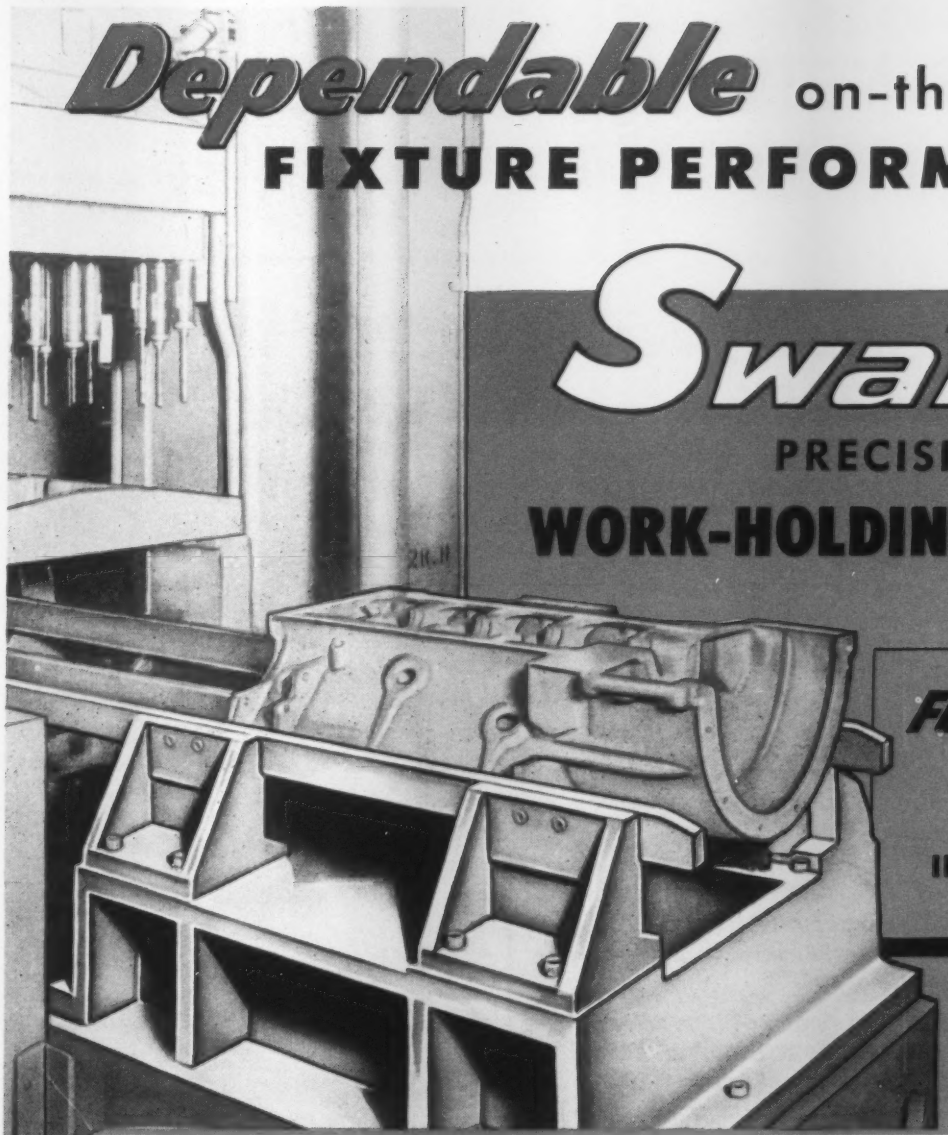


Over-all view of Wean Line that effected tremendous savings in producing giant hulls.

Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

Dependable on-the-job FIXTURE PERFORMANCE!



Swartz

PRECISION

WORK-HOLDING FIXTURES

FOR AUTOMATIC
TRANSFER
and
INDEX MACHINES

It's the dependable on-the-job performance of Swartz fixtures which sums up the many advantages Swartz service provides both buyer and builder of automatic machine tools. That's why Swartz fixtures were specified for this special 14-station Transfer Machine.

More than 30 years of seasoned experience and know-how, together with modern fixture-building facilities, are back of the Swartz specialized fixture-building service. It is an out-of-the-ordinary service, complete in every detail, with a number of distinct advantages . . . advantages it will pay you to investigate.

A Swartz engineer will gladly give you the facts, and point out the many ways this efficient, profitable service can be put to work for you.

WRITE TODAY FOR YOUR COPY OF THE NEW SWARTZ BROCHURE! THE INTERESTING DETAILS OF SWARTZ SERVICE ARE OUTLINED IN THIS NEW BROCHURE, "ADVANCING AUTOMATION," AND A COPY WILL BE MAILED ON REQUEST.

Designers and Builders of Precision Work-Holding Fixtures for More Than 30 Years

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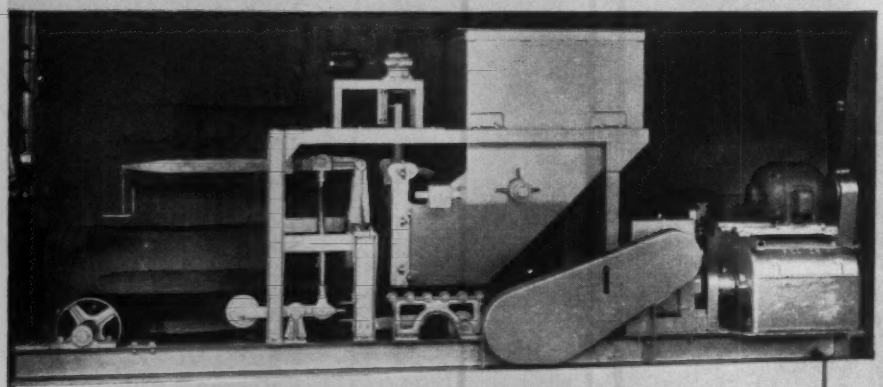
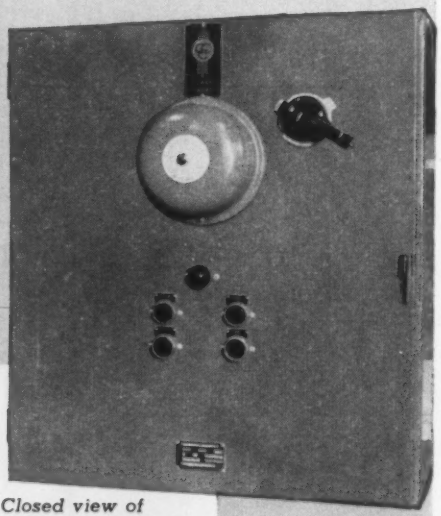
SCHAFFER POIDOMETERS rely on CLARK CONTROL for accurate feeding, weighing and conveying

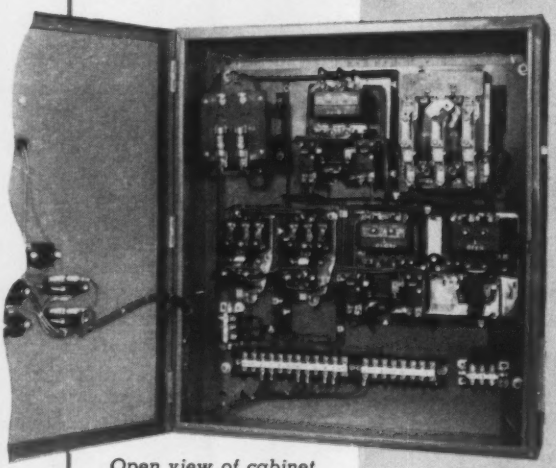
CLARK Type "CY" Starters *are basic units in Control System*



Schaffer Poidometers—Feeder—Weigher—Conveyor



Closed view of Clark Control Cabinet



Open view of cabinet

Dependable, accurate control is essential on poidometers designed to deliver materials to machines or process operations in exactly correct amounts.

The Schaffer poidometer illustrated is one of four which feed clinker and gypsum in lump state to a ball mill for pulverization. The CLARK control panel incorporates controls for two motors—one operating the conveyor belt at a fixed travel speed, the other operating the hopper gate. A weighing beam actuates limit switches, causing controlled motor to move gates up or down, to keep proper weight of material flowing.

When two or more poidometers are used for proportioning materials, controls are provided so that stoppage of one machine automatically stops the others to prevent improper proportioning.

CLARK Type "CY" AC Motor Starters are ideal for this and other control applications where accuracy and dependability are requisites. The new arc-quenching principle, which forces the arc to move continually from a hot to a cold spot on contact surfaces effectively reduces contact wear—thus providing less down time and longer life.

These and other important exclusive features of CLARK Type "CY" Starters can improve the efficiency of your machines. Let us show you how.

The **CLARK CONTROLLER** *Company*

Engineered Electrical Control

1146 East 152nd Street • • Cleveland 10, Ohio

DECEMBER, 1954
Vol. 1—No. 5

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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AUTOMATION OUTLOOK

CORRECT AND ON TIME

". . . paperwork failures result in expensive deviations from management plans. Superb operating facilities are robbed of full efficiency when operating instructions are late or wrong because facilities for processing are antiquated and inadequate. Ability to provide proper information may be balanced to the need for such information by applying mechanization principles to paperwork—integrated data processing . . ."—*P. B. Garrott, director, market development, Standard Register Co.* *See page 31.*

A HIGHER LEVEL

". . . as labor becomes more costly (and we have just witnessed a long period of rising labor costs), more and more machines will take over the control operations. Yet, labor will not become unnecessary. It will merely become more productive. Labor will be required to build the automatic machinery, to assemble its parts, raw materials will have to be supplied to the machine, it will have to be started and stopped, maintained and repaired. Changing requirements will necessitate resetting or rebuilding of the automatic machine. Labor will be cleaner, more attractive and more demanding on the skills of the worker, requiring a higher level of technical education and craftsmanship. Probably the worker will work fewer hours while achieving a higher standard of living. There will be more time for leisure and a greater consumption of those products which leisure requires . . ."—*Chemonomics, R. S. Aries & Associates.*

MORE DOLLARS TO BE SAVED

". . . today, eight times more research dollars are being spent to improve manufacturing as are being spent to improve distribution. This, despite the fact that distribution costs, by and large, take a greater part of the consumer dollar than production costs. It is high time that we applied some of the principles of automation to increasing the effectiveness of our distribution instead of thinking only of increasing the efficiency of our manufacturing . . ."—*Richard Manville, Richard Manville Research.*

HISTORY REPEATS

". . . many have said that automation would displace labor and cause widespread unemployment. Certainly, the same things must have been said about mass production, the invention of the sewing machine, the invention of the steam engine, even the old lamplighter, if you will—in fact, about all of the other significant advances in manufacturing during the last fifty years. In my opinion, automation will do just the opposite. It will create more jobs—create more product at less cost—and increase the ability of people to consume. It is the key to less human effort in the future and an increase in our standard of living of tomorrow . . ."—*D. S. Harder, vice president—manufacturing, Ford Motor Co.*

STEPPING STONE TO EXPANSION

". . . Automation is a vital stepping stone to the expansion of our economy. It has the ability to tie production processes together and to enable labor to gain the most from machines. Extensive use of automation would act as a prod to our entire economy in three ways: (1) By expanding the capital goods industry—building the automation devices; (2) by enabling labor to increase its earning power—higher skills and greater productivity; and (3) by reducing over-all costs of production . . ."—*D. S. Harder, vice president—manufacturing, Ford Motor Co.*

LESS BACKACHE

" . . . and labor has no quarrel with this advancement. Labor unions usually welcome the machines that take the backache out of the stamping shop, remove the need of handling sharp-edged pieces and minimize many safety hazards . . ."—*Francis J. Sehn, Vice President, Sahlin Engineering Co.* *See page 18.*

AUTOMATION

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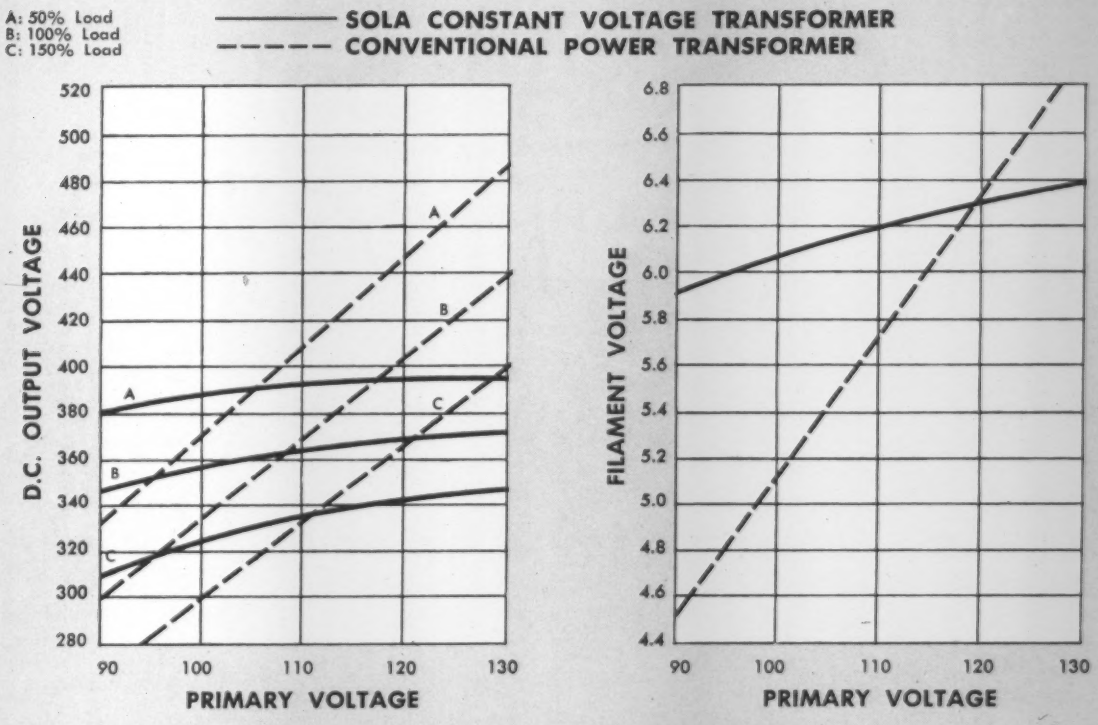


These curves contrast the plate and filament supply voltages obtained from a Sola and a conventional power transformer when line voltage is varied from 100v to 130v.

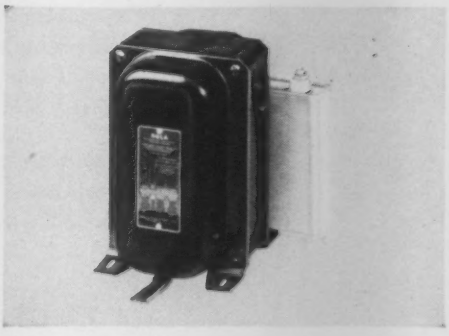
Improve performance of control components with built-in regulating power transformer

You can make sure your product will always receive correct plate and filament voltages by building in a Sola Constant Voltage Power Transformer (Type CVE) in place of a conventional, non-regulating power transformer.

The Sola CVE provides ±3% regulation of plate and filament supply, with line voltage variations of 100 to 130 volts. Regulation is completely automatic, continuous and substantially instantaneous (1.5 cycles or less). Sola CVE stabilizers have no moving parts or tubes, require no manual adjustments or maintenance, and are self-protecting against short circuits.

Three stock units (all with high voltage ct, 5.0v and 6.3v regulated windings) are stocked by your electronic distributor. You can order production quantities of special units manufactured to your specification. We invite your inquiry.

TYPICAL STOCK UNIT: Sola Electronic Power Transformers are made for chassis mounting. They are furnished complete with separate capacitors and capacitor mounting brackets.



Automatic, Maintenance-Free Voltage Stabilization

SOLA *Constant Voltage* **TRANSFORMERS**

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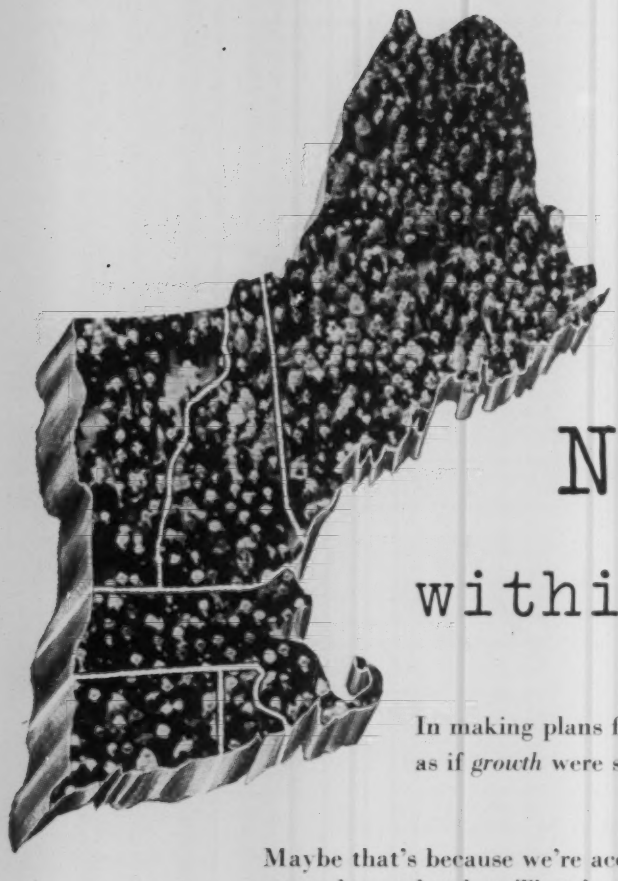
Ask for CIRCULAR 25L-CVE-195

CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414** • *BOSTON:* 272 Centre Street, Newton 58, Massachusetts • *NEW YORK 35:* 103 East 125th Street • *LOS ANGELES 26:* 2025 Sunset Boulevard • *PHILADELPHIA:* Commercial Trust Building • *CLEVELAND 15:* 1836 Euclid Avenue • *KANSAS CITY 2, MISSOURI:* 406 West 34th Street • *Representatives in Other Principal Cities*



ANOTHER New England within the next 4 years

In making plans for the future it's surprising how many of us act as if *growth* were something that is entirely *behind* us!

Maybe that's because we're accustomed to making comparisons of yesterday and today. There's no question about the growth we've had since '40 or '47. Most everyone is now taking this growth into consideration in today's planning.

But what about the growth *ahead* of us? The next time you sit in a planning conference, try this little bombshell:

> **The increase in our population *within the next four years* will be the equivalent of adding *another New England* to the U.S.**

That's just one example of how fast America is *continuing* to grow.

Visualize the opportunity ahead for your Company in such a dynamic and expanding economy. But making the most of such an opportunity is going to take some raising of sights. It's going to require sound sales and advertising planning based on the size of the job *ahead*, and not the size of the job *behind* us.

For help in your planning we invite you and your advertising agency to make full use of the information facilities of the Penton Publishing Company. We will be happy to cooperate with you.

THE PENTON PUBLISHING COMPANY

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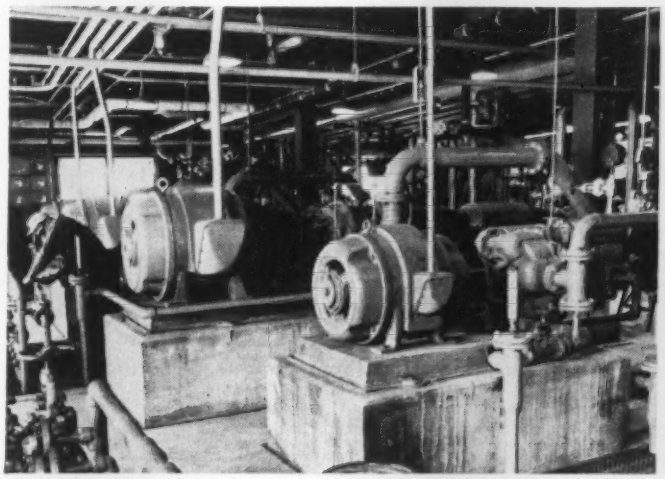
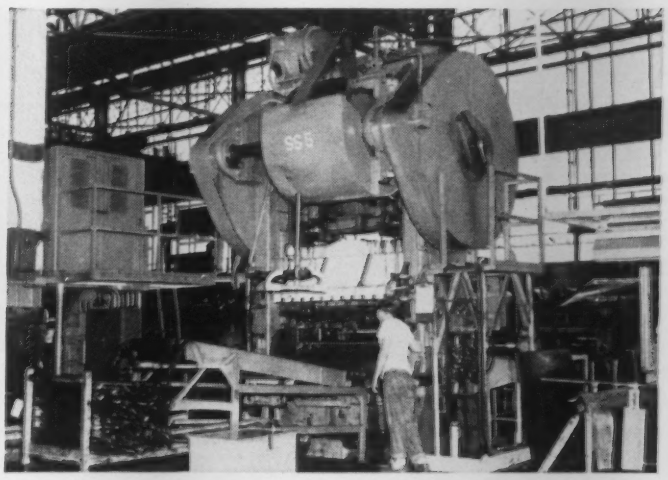
BUILT AND APPLIED BY RELIANCE

THE Tools of Automation

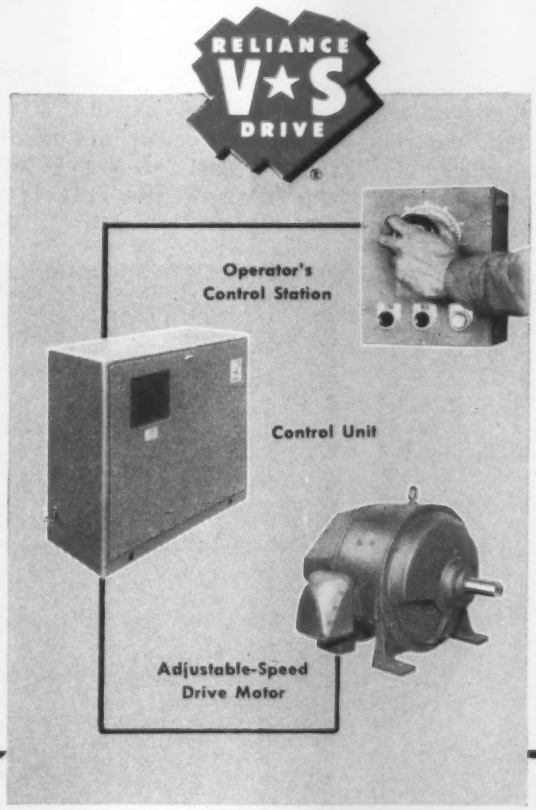
INCREASE PROFITS IN EVERY INDUSTRY



Automation in refineries and the petro-chemical industries is made practical by the choice of the correct Reliance A-c. motors. They provide unfailing power for those processes which go unattended hour after hour.

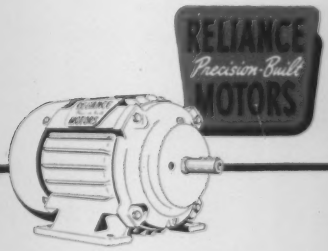


On stamping presses Reliance V★S Drives automatically provide proper metalworking speeds on each cycle, enabling parts to be produced to close tolerances at fast rates of production.



Greater machinery output . . . improved production efficiency . . . both result in increased profits. And both result from using the Tools of Automation: Reliance electric motors, adjustable-speed drives, electronic controls, and applied engineering. They're setting new standards for low cost production in *every* industry.

These Tools of Automation can most efficiently lower your costs, because they're designed and applied to *your* specific situation. Reliance Application Engineers are backed by nearly 50 years' experience in perfecting the drive systems that can help you attain the degree of automatic production you require. For further information, write for the new booklet, "The Tools of Automation". A-1487-D



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AUTOMATION NEWS

Today's events and developments of importance in the field of modern automation

Controls for Papermaking

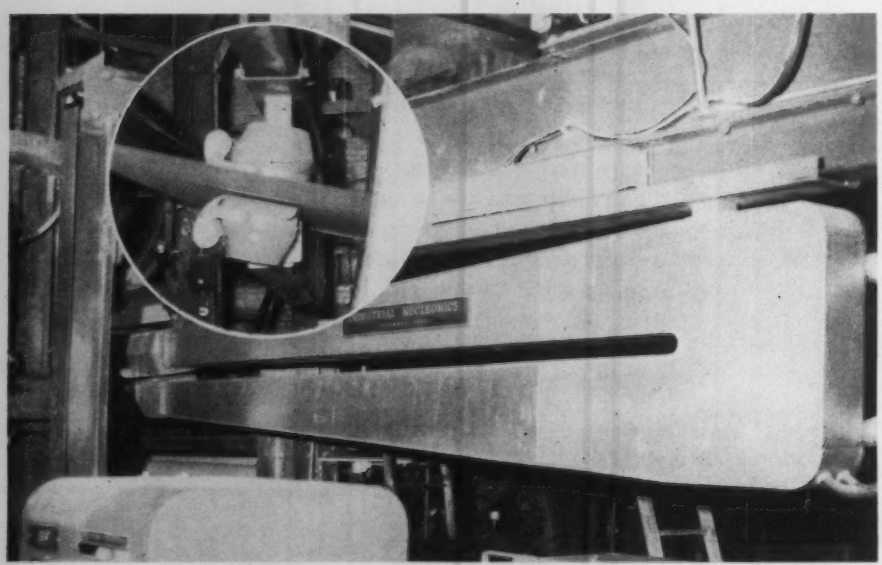
NUCLEAR GAGES and electronic controls are introducing automatic control to papermaking (Aug.—AUTOMATION) at S. D. Warren Co. Control system, designed and manufactured by Industrial Nucleonics Corp., automatically controls amount of liquid pulp introduced into a paper machine. Component parts of system are an AccuRay radiation gage which acts as sensing element for control system; scanning mechanism which enables gage to measure across width of sheet; scanning integrator which averages weight of sheet; and a proportional automatic controller.

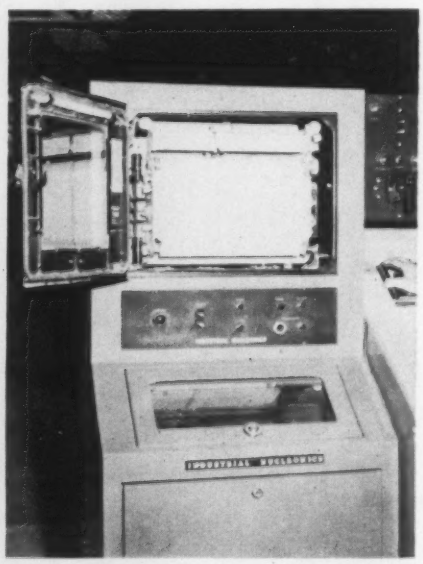
Previously, adjustments to "stuff gate" were made by hand. Amount of pulp added or decreased was determined solely by operators' experience plus his knowledge of the weight of paper samples torn from moving sheets as it came to the winding reel.

Under new system, hand sampling and adjusting are a thing of the past. To detect variations automatically, AccuRay gage was installed after last dryer roll and before windup to measure finished paper at its final weight. Gage measures slowly across width of sheet, presenting its sheet reading profile on a recorder. When gage reaches end of its scan, recorder pen clamps while gage retracts quickly to begin a new scan. During retraction, a scanning integrator averages weight of sheet and flashes its signal to controller. When average is beyond control band set into the controller, action is initiated to adjust flow. Safety devices are incorporated to provide product and process protection i.e., if equipment failures are encountered or if unusual process conditions prevent controller from making proper corrections, automatic control terminates and an alarm sounds to inform operator.

Uniformity of paper weight is of great importance to the printing industry where printing presses are set up to handle certain weight stocks. A variance in weight can result in poor printing and re-runs with consequent loss of money and time.

Due to the complex nature of paper machines, completely automatic process control is still in the future. However, automatic control of basic weight is bringing this dream closer to realization.





SYSTEM AUTOMATICALLY controls amount of liquid pulp introduced into a paper machine. Unit shown (left) in off-sheet position, scans back and forth across paper continuously, presents sheet reading profile on a recorder. When gage reaches end of its scan, gage retracts to begin new scan. During retraction, scanning integrator records weight of sheet and flashes signal to controller where action is initiated to adjust flow if average is incorrect. Insert shows front view of gage measuring across sheet. Operator's control station (right) for automatic control system consists of recording console and control box.

Promotions

IN A RECENT announcement, two new vice presidents and three assistant vice presidents were named by Robertshaw-Fulton Controls Co.

Woodford D. Miller, formerly assistant vice president, has been moved up to vice president. He will continue as manager of the company's Robertshaw Thermostat Div., which operates plants at Youngwood, Scottdale and Indiana, Pa.

Wilbur Jackson, works manager at the Grayson Controls Div., Lynwood, Calif. has been promoted from assistant vice president to vice president.

Mr. Miller has been associated with the company or its predecessors since June, 1936, when he was employed as an engineering trainee at the Fulton Sylphon plant in Knoxville, Tenn. In the succeeding five years, he moved up through various engineering and sales positions, and in 1941 became assistant purchasing agent.

He was transferred to Robertshaw Thermostat Co. in 1943, became director of material in 1948, and was assistant vice president and plant manager on January 1, 1952.

Mr. Jackson, a native of Buxton, Iowa, was one of the first two employees of the Grayson organization when it was formed in 1929. He has been associated with various phases of controls manufacturing and processing.

The three new assistant vice presidents are: **Frank H. Post,** who also becomes sales manager, Cooking Appliance Controls Div.; **Alton W. Beck,** who is also sales manager of the Heating Appliance Controls Div., and **John A. Robertshaw, Jr.,** manager of foreign operations.

Designed for Standardization

DESIGNED to work from standard 5-hole code tape, new Graphotype machine developed by Addressograph-Multigraph Corp., makes it possible to automatically make Addressograph self-writing master record plates from standard teletype tape, produced from tabulating cards, on an electric typewriter, or by a teletype perforator.

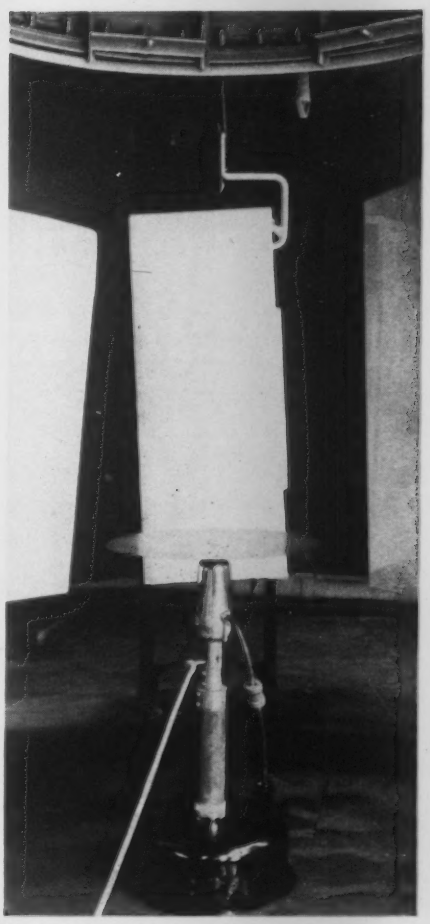
Names, descriptions, figures and other repetitive data can now be transmitted from distant points to a central office, or vice versa, over telegraph wires and as a by-product a tape is prepared. This 5-hole code tape can then be used to make Addressograph plates without a Graphotype operator and without intervening re-writing or other machine operations. Information not pertinent to permanent records can be automatically deleted.

Electrostatic Painting

RECIPROCATING disk-type atomizer used with electrostatic spray painting has been developed by Ransburg Electro-Coating Corp. of Indianapolis. Although a number of stationary atomizers already are in use in finishing departments, reciprocating adaptation is new. Up and down motion improves uniformity in painting not only small parts but products such as refrigerator cabinets and doors.

Parts are hung on a conveyor which makes a circular loop in the electrostatic spray area. The reciprocating disk atomizer is located in a pit in the floor (or mounted overhead) in the center of the loop. Paint is pumped to the rotating disk charged with high dc voltage (usually around 90 kv) establishing an electrostatic field between the disk and parts hanging on the grounded conveyor. This atomizes the paint into a fine spray and electrostatically attracts it to the surrounding parts. No compressed air or water-washed booth is required.

Reciprocating disk-type atomizer does not require precise positioning of parts in relationship to the atomizer. Tests show the unit will tolerate a 10 to 24-inch difference with practically no spray pattern problem. The reciprocating disk permits application of a heavy, uniform coating with one pass in the electrostatic spray area. With refrigerator whites, up to 2 mils are applied with one pass through the paint area.



PARTS ARE HUNG on a conveyor which makes a circular loop in the electrostatic spray area. Reciprocating disk atomizer is located in a pit in the floor (as shown) or mounted overhead in center of loop. Paint is pumped to the rotating disk charged with high dc voltage establishing an electrostatic field between disk and parts hanging on grounded conveyor. Objects to be painted may get 26 sixty-inch strokes which is actually comparable to a number of passes in a stationary disk painting area.

Back to School

EACH WEEK-DAY morning business executives, clerks, college students and educators enter Electro Data Corp.'s computing center to learn the new language of the electronic digital computer.

Several types of instruction in electronic data processing are offered. Two week course, covering 80 hours of classroom computer work is given twice each month to teach those attending how to program and code problems using any modern electronic computer. This affords students an opportunity to evaluate present capabilities of electronic data processing and its adaptability to their own specific business problems.

Customer orientation instruction provides an intensive three week course in computer maintenance and operation in addition to the

coding program for personnel of companies that have ordered a computing system. A financial aid fellowship program is also offered to leading universities by Electro-Data to provide tomorrow's industrial planners with first hand computer experience. In July 1954, two Purdue University graduate mathematics students became first participants in a computer instruction fellowship when the company made a grant of $1,000 to underwrite expenses of computer trainees.

ONE-DAY CONFERENCE on automation was held recently in Davenport Masonic Temple under joint sponsorship of Quad-City chapter of American Material Handling Society Inc., Iowa-Illinois section of ASME, Quad-City association of Time-Study Engineers, and Associated Industries of the Quad-Cities. Approximately 500 persons from all parts of the country listened to addresses throughout the day by Del S. Harder, Charles Hautau, John Diebold, Herbert L. Tigges and Roger W. Bolz. Special feature of the conference was a visit to six area plants during morning session. Shown above from left to right are Charles Hautau, guest speaker, president Hautau Engineering Co.; Roger W. Bolz, guest speaker and session moderator, editor AUTOMATION; R. L. Franing, session moderator, International Harvester Co.; Richard H. Burke, Associated Industries of Quad-Cities; and Al Groschow, Hautau Engineering Co.

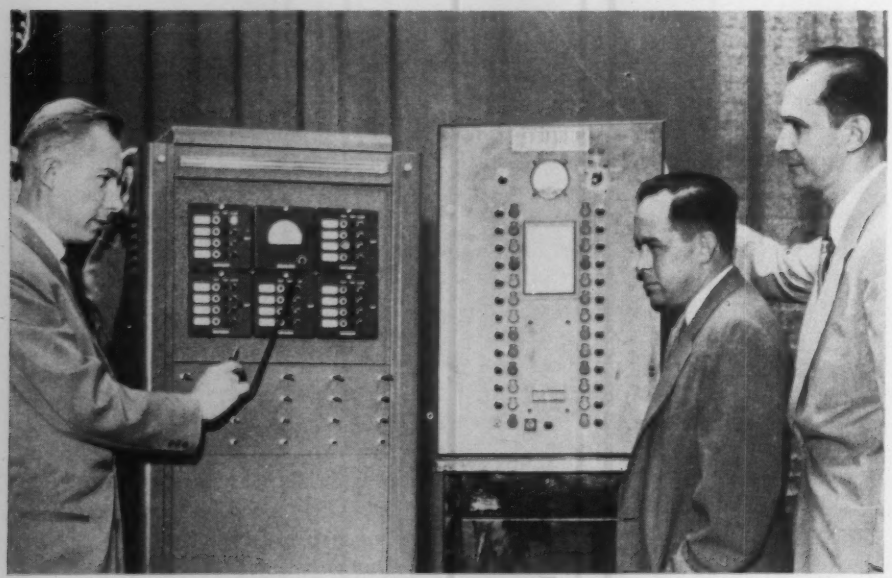
Temperature Monitoring System

TO ELIMINATE THOUSANDS of man-hours spent in making rounds, periodically feeling bearing casings or reading thermometers scattered over a wide area, the Instrument Div. of Thomas A. Edison Inc. has introduced a new flexible temperature monitoring system.

Designated Omniguard, new equipment is designed to protect a few or several hundred remotely scattered points from temperature excesses. Building block design permits original installations to be added to without disturbing or effecting existing units or wiring. To lower installation costs considerably, system is planned so that monitor units and indicator can be mounted close to equipment to be protected and at same time a master alarm signal can be carried through a single pair of copper wires to a central control which may be a considerable distance away.

In use, each individual circuit operates on resistance bridge principle. For temperature measurement, an Edison resistance thermometer makes the fourth arm of the bridge circuit. Detecting portion of bridge is a relay adjusted so that its contacts close as the alarm point is reached. Relay in alarm circuit then closes so that sensitive relay is removed from circuit. This relay also has extra sets of contacts to actuate a master audible alarm and an annunciator unit in the control room.

Equipment monitors each point simultaneously—without scanning. Thus no point is left unguarded even when several hundred points are under surveillance. Omniguard automatically sounds a warning when a given point or points reach "critical" temperature. By maintaining a close watch of bearing temperatures, production can be increased without danger of an unexpected breakdown. Monitoring device also offers the possibility of increasing peak loads with safety and of maintaining them longer because warning is given before temperature reaches danger point.



NEW SYSTEM, Omniguard, is demonstrated to Mr. Kenneth Roe (center) by V. W. Rose and H. R. Karp of Edison's Instrument Division. Equipment is designed to protect a few or several hundred remotely scattered points from temperature excesses.

Research Consultant

DEAN OF TECHNOLOGY, University of Minnesota, **Dr. Athelstan Spilhaus,** has been retained by Minneapolis-Honeywell Regulator Co. as a consultant in the fields of engineering and research. He will assist in formulating broad engineering and research policies aimed at continued expansion of development work in the many technological branches in which the company is active.

Spilhaus, who has been dean of Minnesota's Institute of Technology since 1949, also serves as a consultant to a number of government and military agencies, including the Department of Defense and Weather Bureau.

V. P. Appointed

APPOINTMENT of **Charles Brunell** as vice president in charge of sales for Cook Electric Co. has been announced. Brunell has been manager of the company's Diaphlex Div. since 1949. Prior to joining Cook, he worked for Douglas Aircraft as an aeronautical engineer and for Goodyear Aircraft as a design engineer.

Portable Spectrometer

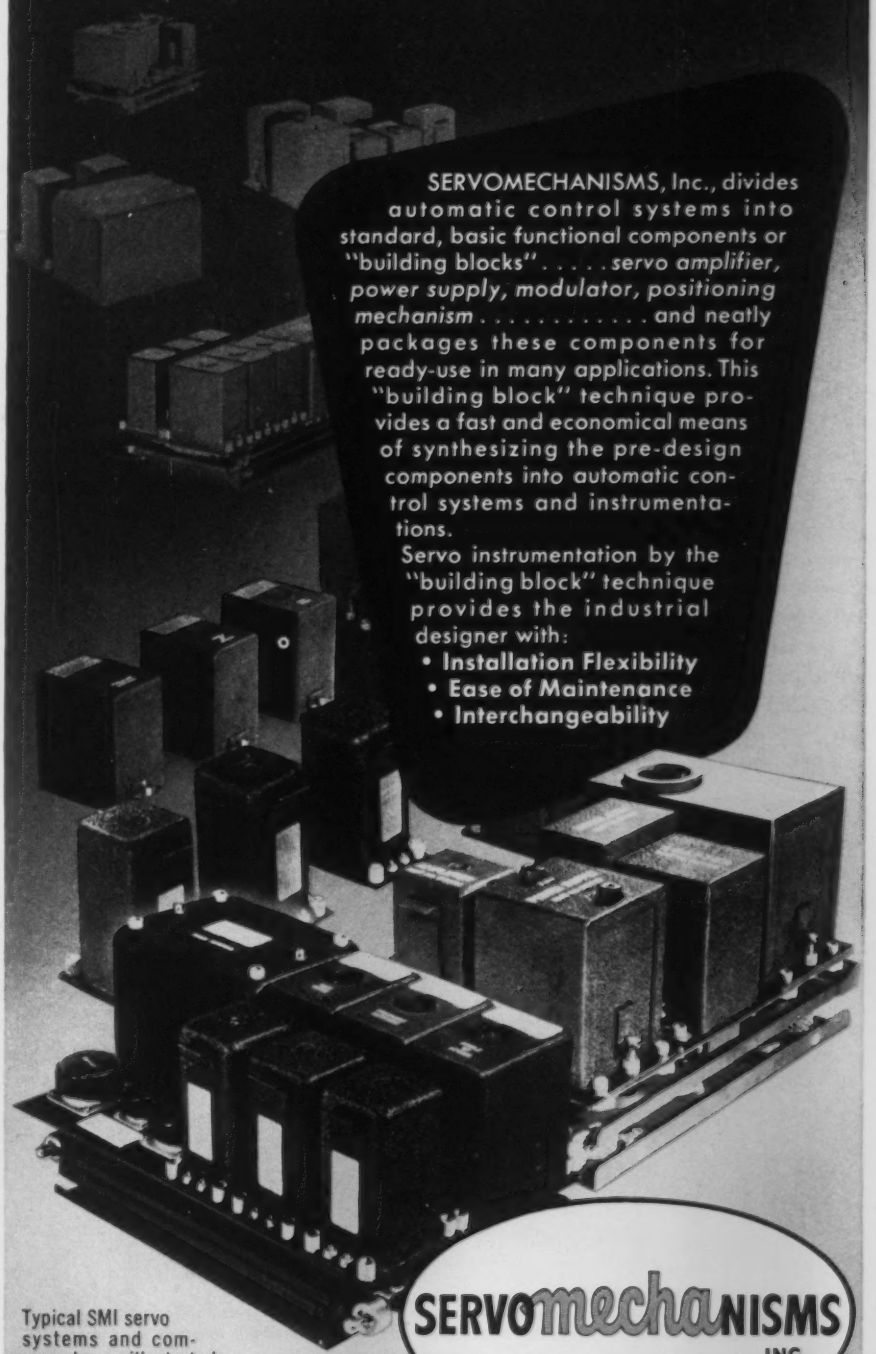
INTRODUCED by Consolidated Engineering, a mass spectrometer meter furnishes the petroleum, chemical and petrochemical industries with a portable unit for making rapid analyses of gaseous and light liquid mixtures with accuracy comparable with much larger units. It is specially designed for process steams including continuous monitoring systems as well as conventional laboratory applications. In process control, it may be coupled directly into the steam.

Expansion

CONTINUING a program of expansion into the electronics field, Brush Electronics Co., Div. of Clevite Corp. has purchased the assets of Digital Instrument Co., manufacturer of a complete line of electronic counters. It was announced that **Meryl C. Burns,** former president of the Florida concern, will serve as manager of the Digital Instrument Dept. of Brush Electronics.

Products formerly manufactured by Digital will be integrated into the Brush line. Digital counters are designed for high-speed counting where exceptionally high accuracy and rapid control are vital factors, and are especially valuable where mechanical equipment can-

AUTOMATIC CONTROL SYSTEMS
for all applications
INDUSTRIAL and MILITARY



SERVOMECHANISMS, Inc., divides automatic control systems into standard, basic functional components or "building blocks" . . . . . *servo amplifier, power supply, modulator, positioning mechanism* . . . . . and neatly packages these components for ready-use in many applications. This "building block" technique provides a fast and economical means of synthesizing the pre-design components into automatic control systems and instrumentations.

Servo instrumentation by the "building block" technique provides the industrial designer with:

- Installation Flexibility
- Ease of Maintenance
- Interchangeability

Typical SMI servo systems and components are illustrated.

SERVOmechaNISMS INC.

For information on specific applications, write to
WESTBURY, N.Y. • EL SEGUNDO, CAL.

not do the job. They are presently used extensively in the aircraft industry in inspection of jet engines, in industrial and commercial test laboratories, and are serving an important function in the guided missile program. Their application in the expanding computer field and in control and automation processes is rapidly increasing.

Machine Monitoring Device

DEVELOPED to give an instantaneous and permanent record of machine operation, cycle and down time, the new Alden 30-channel recorder can monitor operation of up to 30 machines. Any type of motion or activity can be recorded wherever a simple switch can be attached.

Electrosensitive paper, which uses electricity as ink, makes it possible to pass current from stylii through paper and make a mark. When electricity flows, there is a mark. When there is no electricity, no mark is recorded. Current to activate stylii is picked up by tiny switches mounted on machines or equipment where record of activity is needed. Switches are activated by motions of machine or equipment. Visible, permanent recordings of machine operation are possible. Machines can be monitored remotely and records can be studied for optimum scheduling, breakdown, setup time, delays, efficiency, and cycling.

New Facilities

OPENING OF a new plant, to house automatic research and experimental activities, was announced today by **Richard Sahlin,** president of Sahlin Engineering Co. Typical of the automation machinery to be built in the new plant are transfer machines for sheet metal lines. Used in conjunction with the Iron Hand unloaders and placed between assembly line presses, these units receive a stamping from the unloader, turn it over and move it into next press. Transfer machines are standard, self-contained and easily adaptable to model changeovers.

The company, which was formed seven years ago to manufacture unloading machines will continue its manufacturing operations at Detroit, Flint and Hazel Park. Engineering and general offices will be located in the new plant.

Name Changed

WEST COAST affiliate of B-I-F Industries Inc., Builders-Pacific Inc. has changed its name to B-I-F Pacific Inc. to more closely identify this division with parent organization. With offices in San Francisco, Los Angeles and Phoenix, B-I-F Pacific will continue as sales and service representative for Builders-Providence Inc., Omega Machine Co. and Proportioneers Inc.

Added Responsibility

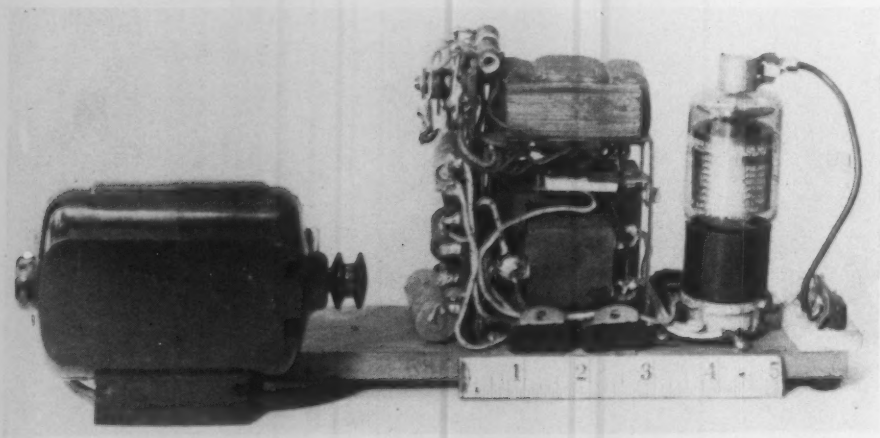
APPOINTMENT of **Clifton T. Foss** as assistant general manager of Arma Div., American Bosch Arma Corp. was recently announced. Mr. Foss continues as vice president-engineering of the division which produces missiles,

weapon-control and navigation systems, and precision industrial control systems for Armed Forces and Atomic Energy Commission. Before coming to Arma in 1933, he was with International Communications Laboratories.

Potential Strength Increased

BY JOINING FORCES, potential strength of two established companies, Gear Grinding Machine Co. and Republic Gear Co., has been enhanced. In a $2,700,000 transaction, "Geargrind" has acquired all of the assets of Republic Gear and its wholly owned subsidiaries, Detroit Bevel Gear Co. and Almetal Universal Joint Co. of Cleveland. Geargrind will control operation, but the entire executive management team of Republic and its subsidiaries will be retained without any major changes of past policy.

Republic and its subsidiaries manufacture transmission, flywheel and timing gears; timing chains, axle shafts for universal joints; and have recently introduced a line of automatic trans-



NETWORK OF FOUR static components provide phase shift up to 360 degrees for VecTrol phase shifter. Linear proportional phase shift of 180 degrees is obtainable with small change of either inductance or capacitance; as little as ±1 per cent at high frequencies or ±20 per cent at low frequencies, with negligible time constant. Unit uses saturable reactor as variable inductance for control of thyratron outputs up to several kilowatts, from zero to maximum, with dc control signal less than 1 milliwatt. All control tubes are eliminated in feedback circuits for voltage regulated power supplies, motor drives, speed controls, servo motors etc. VecTrol phase shifter is a development of Brownthorn Electronics Inc.

missions and auto transmission parts.

Geargrind product, Rzeppa Universal Joints, will complement Republic's line of automotive truck and industrial joints. Their production capacity for close tolerance, fine finished gears will also be enlarged by Bevel Gear's blanking, shaping and finishing capacities. In addition, Bevel Gear facilities will be used for component parts on new Geargrind screw machine and Detroit Screwmatic 750.

Performance Study

WITH AN EYE TOWARD development of equipment and methods which will reduce or eliminate operations currently done by hand, William Brand & Co. Inc., is making a detailed study of the performance of newly developed induction heating units for bonding stranded wire during cutting and stripping operations. This study is being conducted in their own plant as well as plants of copper conductor suppliers, users of plastic insulated wire, and a manufacturer of the induction unit.

While most of the work is being done on Brand's 80, 90, and 105 degree Turbo insulated wires, tests have also been made on air-frame wire, "black-box" wire and various other commercial and military types. A preliminary report giving first findings has been issued.

Systems Consultant Appointed

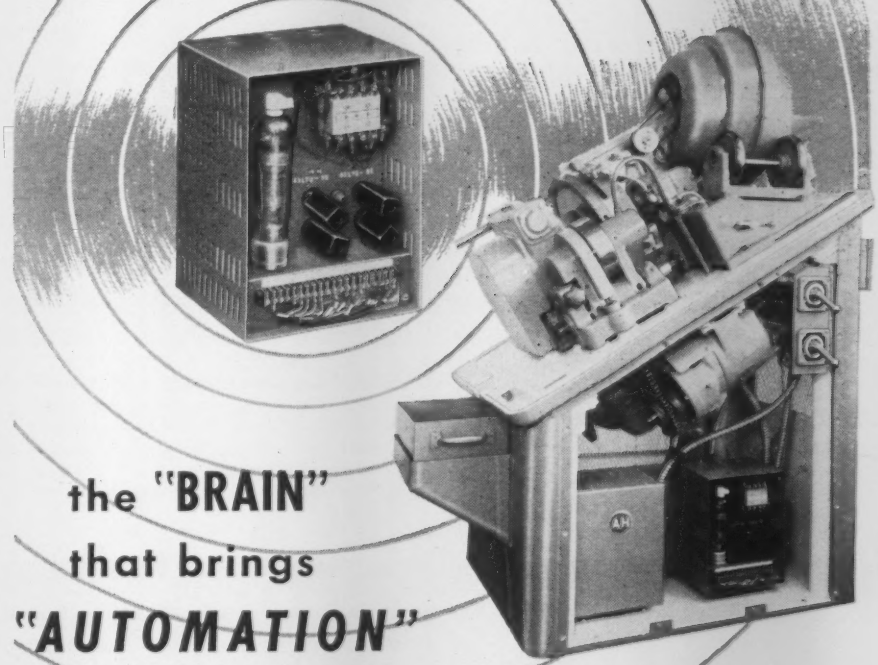
MANUFACTURERS of hammers and other forging equipment, Chambersburg Engineering Co. has announced the appointment of **C. D. Galloway, Sr.,** as special consultant on automatic handling systems for the Chambersburg Impacter, new horizontal forging hammer that strikes metal from both sides simultaneously.

Galloway was employed for 34 years by the Electric Storage Battery Co., Philadelphia, Pa., and at the time of his retirement in 1951 was factory engineer for all plants. During this time he obtained several patents in the special handling and conveying field relative to storage battery

ARROW·HART

Electronic

VARIABLE SPEED DRIVE



the "BRAIN" that brings "AUTOMATION" to this NEW ROY SCREW SLOTTER

Manufactured by the Gros-ite Manufacturing Co. and sold exclusively by Roy Machinery and Sales, Inc., both of Hartford, Conn.

THANKS TO ARROW-HART CONTROL . . . this new machine achieves a degree of automaticity, versatility and productivity that far surpasses any previous models. Screw blanks are simply placed in the hopper . . . finished work is discharged into the basket in the front. The variety of screw sizes and types handled by the Roy Slotter formerly required 5 different machines.

For any fractional horsepower variable speed application, the new Arrow-Hart Packaged Drive offers many important advantages including: low cost; a wide, stepless range of speeds (up to 100 to 1 if required); speeds held substantially constant with varying loads; dynamic braking; instant reversing; and all plug-in replaceable parts for easy maintenace. Use of the series motor provides higher breakaway torque at any speed setting plus faster acceleration.

ARROW-HART

ARROW AH HART

Quality

- MOTOR CONTROLS
- WIRING DEVICES
- ENCLOSED SWITCHES
- APPLIANCE SWITCHES

INDUSTRIAL CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN STREET, HARTFORD 6, CONNECTICUT

Please send my copy of the A-H Variable Speed Drive Bulletin.

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A

SALES ENGINEERS AND BRANCH WAREHOUSE STOCKS IN PRINCIPAL CITIES THROUGHOUT THE COUNTRY

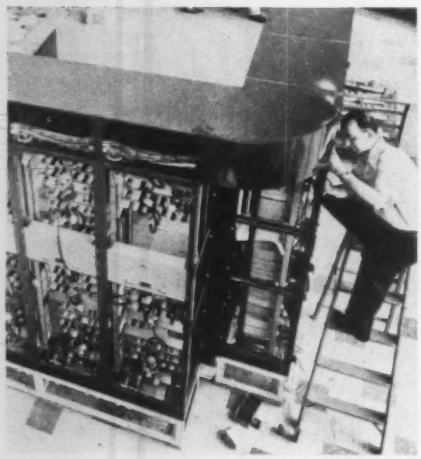
Electronics Instrument Division

AN OUTGROWTH of Research Center at Paoli, Pa., new Burroughs' Electronic Instrument Div. Philadelphia, was recently established and is now handling the development, manufacture, and sale of new electronic equipment.

Special project of new division is operating a computation center which features Burroughs' (UDEC II) Unitized Digital Electronic Computer. This large scale general purpose computing system is performing services for business, industry, science and education in the Philadelphia area on an hourly fee basis. Unit is constructed from 642 "building blocks", individual electronic chassis or pulse panels connected into a logical computation system.

Through changes in cable connections between individual pulse units, Burroughs can easily modify logic of UDEC II and adapt it to new input-output devices.

General manager of the newly formed division, Perry C. Smith, joined Burroughs in 1950 as division director of basic research.



PART OF SIXTY-FOOT rack which holds 642 individual pulse chassis that make up UDEC II is shown being assembled in U-shape to conserve space. Burroughs' technicians are placing "building-block" units in 31 cabinet racks.

COMPOSED OF UNITIZED pulse chassis which are available individually or in any combination to business, research, or teaching institutions, UDEC II is being rented on an hourly fee basis. This Unitized Digital Electronic Computer is quartered in Burroughs' new computation center.

for investment and no public distribution of securities is contemplated. No change in management is planned.

Personnel Changes

SEVERAL CHANGES in executive personnel were recently announced by Continental Industrial Engineers Inc., builders of automatic industrial furnaces and designers and builders of automatic production lines and complete industrial plants.

H. L. Wentworth has been named vice president and also chief engineer. **R. E. Angley** is now manager of estimating and sales engineering for complete plants, production lines, special machines etc. **W. G. Wilson** is the new chief design engineer and **A. C. Graebner,** formerly sales representative with Fahralloy Co. has been appointed as a sales engineer for the company. **R. E. Liston,** formerly assistant purchasing agent, now heads this department.

Modern Alchemy

RESEARCH is turning waste straw into gold for some American farmers. A new paper-pulping method, the mechaniochemical process is responsible. Developed at Northern Regional Research Laboratory, the process yields more pulp from straw than is normally obtained from wood. When blended with wood pulps, residue straw pulps are said to be as strong as soft-wood kraft pulps. Process has proven sufcessful in commercial trials for making fine and corrugated papers and newsprint.

Flexible Financing

MANUFACTURER of mechanical and hydraulic presses, E. W. Bliss Co. announced recently that its five year association with CIT Corp., industrial financing firm, (Oct.—AUTOMATION) has been extended due to continued customer acceptance of the deferred payment plan. Under Bliss-CIT financial program, buyers make a 25 per cent

manufacture. He is currently retained by the Electric Storage Battery Co. as adviser on mechanical processes.

Facilities Combined

HAVING ACQUIRED working assets of Hammond Mfg. Corp. recently, G. L. Ohrstrom Associates will merge and operate Consolidated Tool and Products Co. which they purchased last January as part of Hammond Mfg. Corp. Combined properties will continue to manufacture a line of ground handling equipment for the aviation industry as well as similar equipment for guided missiles. Hammond will be an addition to Ohrstrom aviation and electronics interests which include Leach Corp., Palmer Electric Mfg. Co., Jeffries Transformer Co., Inet, as well as Consolidated Tool and Products Co.

Hammond acquisition was made

down payment to Bliss and pay remainder in 12 to 36 monthly installments to CIT Corp.

MEETINGS AND EVENTS

Dec. 2-7—

ASME National Exposition of Power and Mechanical Engineering. Twenty-first exposition to be held Commercial Museum, Philadelphia. Additional information may be obtained from E. K. Stevens, exposition manager, 480 Lexington Ave., New York 17.

Dec. 3—

Philadelphia Section, Instrument Society of America. All day symposium on "The Automatic Plant" to be held Commercial Museum, Philadelphia in conjunction with 21st National Exposition of Power and Mechanical Engineering. Additional information may be obtained from W. J. Leighton, 2100 Arch St., Philadelphia 3.

Dec. 8-10—

Eastern Joint Computer Conference and Exhibition. Fourth annual conference and exhibition to be held Bellevue-Stratford Hotel, Philadelphia. Additional information may be obtained by writing Eastern Joint Computer Conference, P. O. Box 7825, Phila. 1.

Dec. 12-15—

American Institute of Chemical Engineers. Annual meeting to be held Hotel New Yorker, New York. Additional information may be obtained from Stephen L. Tyler, 120 E. 41st St., New York 17.

Jan. 10-14—

Society of Automotive Engineers. Golden anniversary annual meeting and engineering display to be held Sheraton-Cadillac Hotel and Hotel Statler, Detroit. Additional information may be obtained by writing society headquarters 29 West 39th St., New York 18.

Jan. 13-14—

AMA Office Management Seminar. Third of three meetings to be held AMA headquarters, New York, on initiating and developing an office-work simplification program. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

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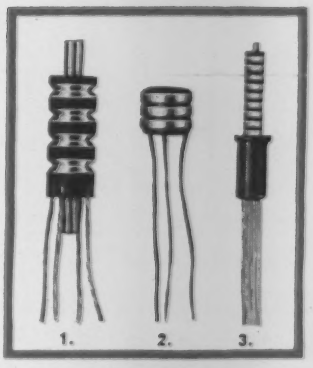
FOR SLIP RING ASSEMBLIES NO BIGGER THAN THIS CALL P M I.

Slip ring assemblies we have made measure no more than .080" diameter by .450 inches. We can make them smaller or larger, with more or fewer circuits. Many of our miniature slip ring assemblies are carried in stock and can save you development and die costs. Ask for booklet, "Miniature Slip Ring Assemblies."



ACTUAL SIZE

1. Coin silver rings molded in melamine.
2. Gold rings molded in nylon.
3. Plated rings in cast resin.

P M I

P M INDUSTRIES, INC.
282 FAIRFIELD AVENUE
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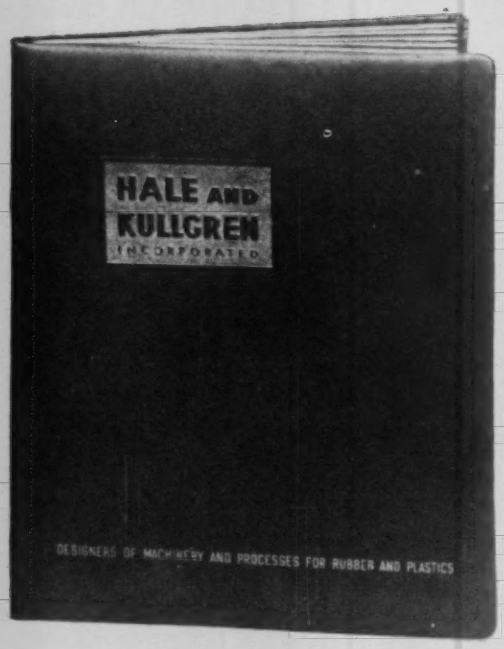
if you want to **lower** your manufacturing **costs**

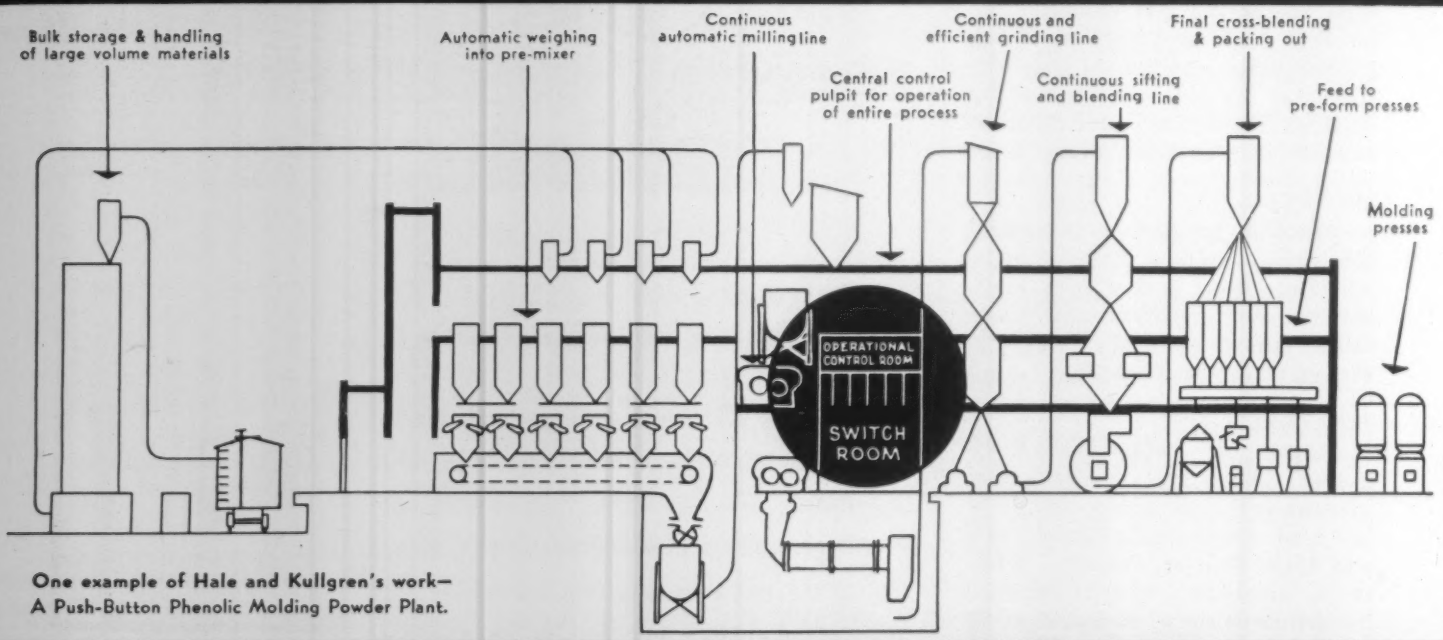


Cost of a preliminary study for you is low.

If you can improve your conversion and material costs, your profit picture will benefit.

Maybe you can and maybe you can't, but Hale and Kullgren can guide you. Hale and Kullgren's experience can be of invaluable help in applying the principles of automation to accomplish cost reduction in your plant.

For example, here is what Hale and Kullgren will answer in a study of your plant, or plants, or department: Proposed ultimate production schedule; plant layout — present and future; description of proposed processes, including direct and indirect labor requirements; detailed description and cost of plant modifications and new equipment; projected manufacturing costs based on modernized plant and processes; appendix of supporting data. The cost of a study is low.


Bulk storage & handling of large volume materials
Automatic weighing into pre-mixer
Continuous automatic milling line
Central control pulpit for operation of entire process
Continuous and efficient grinding line
Continuous sifting and blending line
Final cross-blending & packing out
Feed to pre-form presses
Molding presses
OPERATIONAL CONTROL ROOM
SWITCH ROOM

One example of Hale and Kullgren's work—
A Push-Button Phenolic Molding Powder Plant.

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Hale and Kullgren offers a complete service to anyone making or processing rubber or plastics. They can engineer and build a complete plant, develop a specialized process and design special equipment. They are specialists in automation as applied to the rubber and plastics industry. You will be interested in your own study, plus examples of what they have done for others.

CONSULTANTS FOR RUBBER AND PLASTICS

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associated with The Aetna-Standard Engineering Co.
MACHINERY BUILDERS

DECEMBER 1954

Hard Cold Facts

In making a careful study of automation from its inception, it is not in the least amazing or unusual that a neat and integrated picture reveals itself. From groundwork laid before the turn of the century, it has developed into today's dynamic and fast-emerging technology.

Unheralded and unsung, the slow and laborious steps toward today's accomplishments have made possible our fabulous standard of living. The accelerated trend toward more automatic operations in recent years has merely shed dramatic light on these engineering achievements which are often ignored or misrepresented. Without a doubt this new light has been valuable in answering the question of management, "Is it a practical tool for industry or is it a fantasy woven around a thread of fact?"

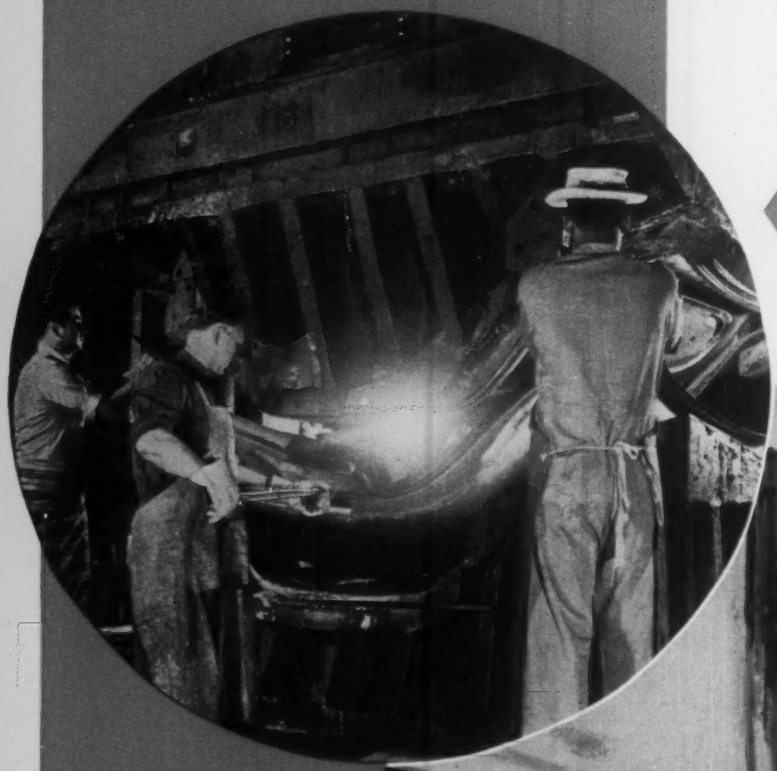
A practical and down-to-earth reality, automation on a broad scale offers an economic answer to today's needs that yesterday's market could use only in scattered areas. From the numerous successful examples of automation found today throughout all industry, unusual economic, commercial and industrial opportunities are evident. But evident also is the fact that its tremendous breadth, scope and influence make full understanding a problem.

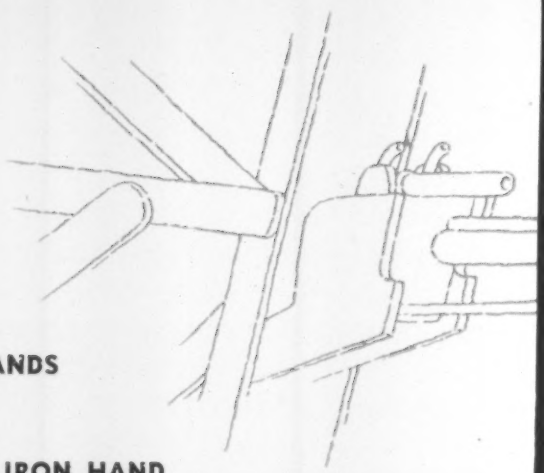
To meet the demands arising daily in this dynamic economy, there is a vital need for basic facts and "know-how" on overall automatic operations. Emphasizing this need, at a recent engineering meeting it was pointed out that the hard, cold facts on automation, whatever they are, have been buried under a profusion of words, and more practical information applicable to present problems is wanted.

Practical hard, cold facts of automation are available. Automation succeeds *only* where it meets the real test of economics, not fantasy. It has met the test and is doing so on an increasingly broader scale. The basic ingredients in components, equipment and systems can be readily found; ingenious practical application is needed. This is the role of AUTOMATION; to detail, record and catalyze the technology of automation into ever greater advances—more and better goods at lower cost, less hard work, better jobs, and increased emphasis on initiative and judgment.

H. A. Bolz

EDITOR





SIX HANDS

IRON HAND

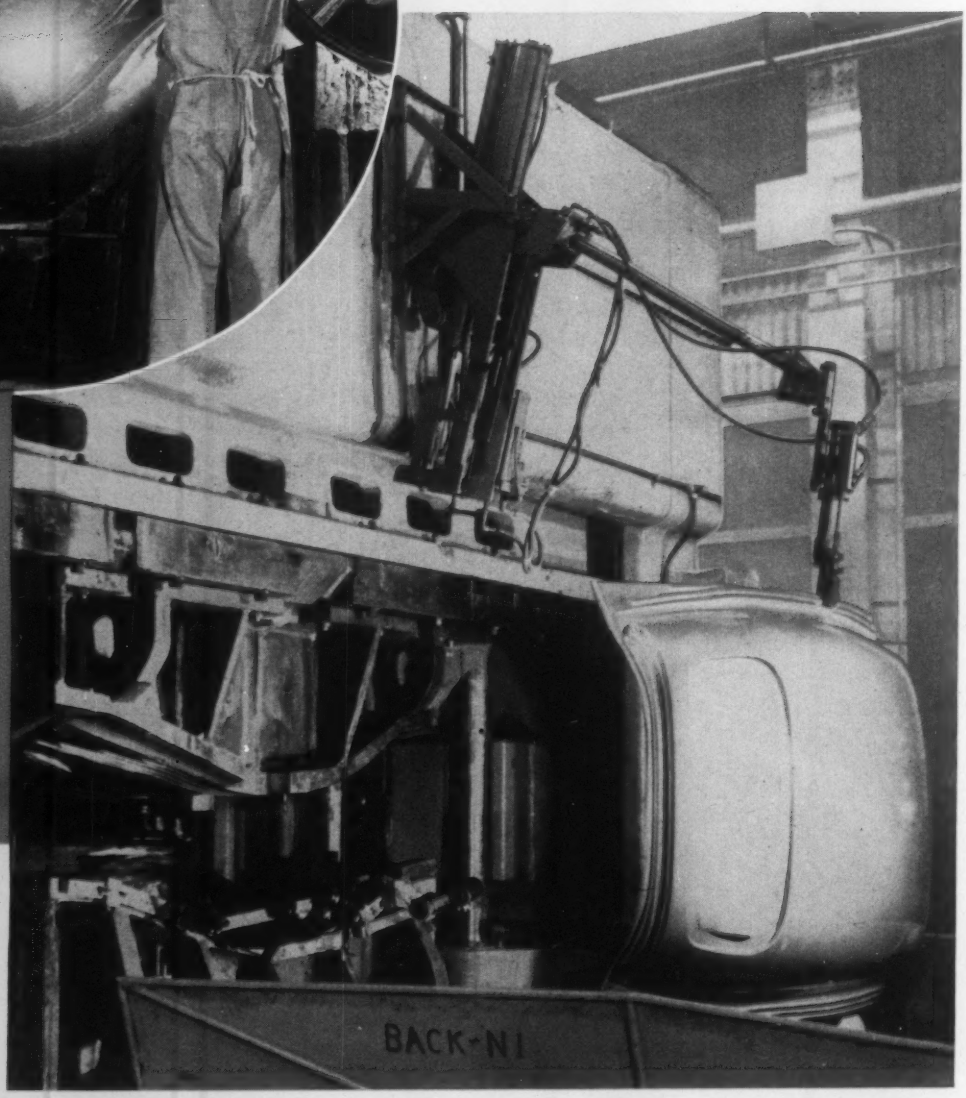
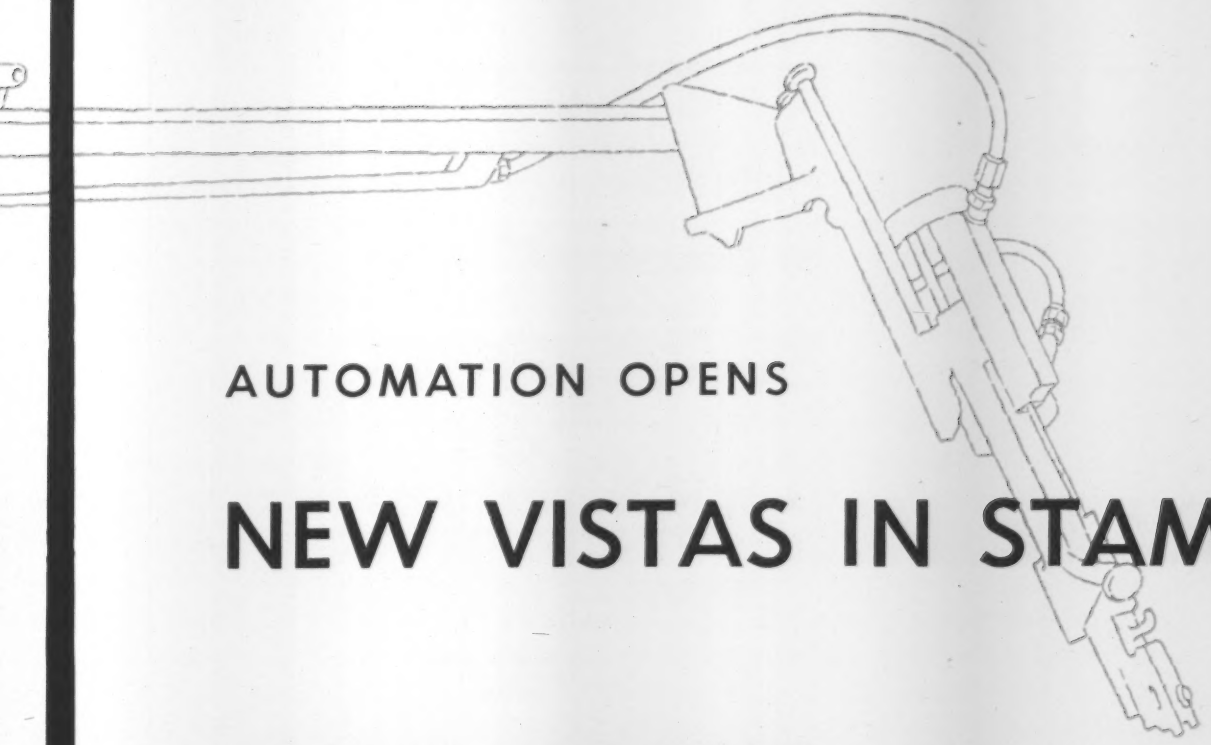


Fig. 1—Automotive presswork unloading operations were formerly back breaking and hazardous. Modern automatic unloading device removes 80-pound auto top from the press and turns it over

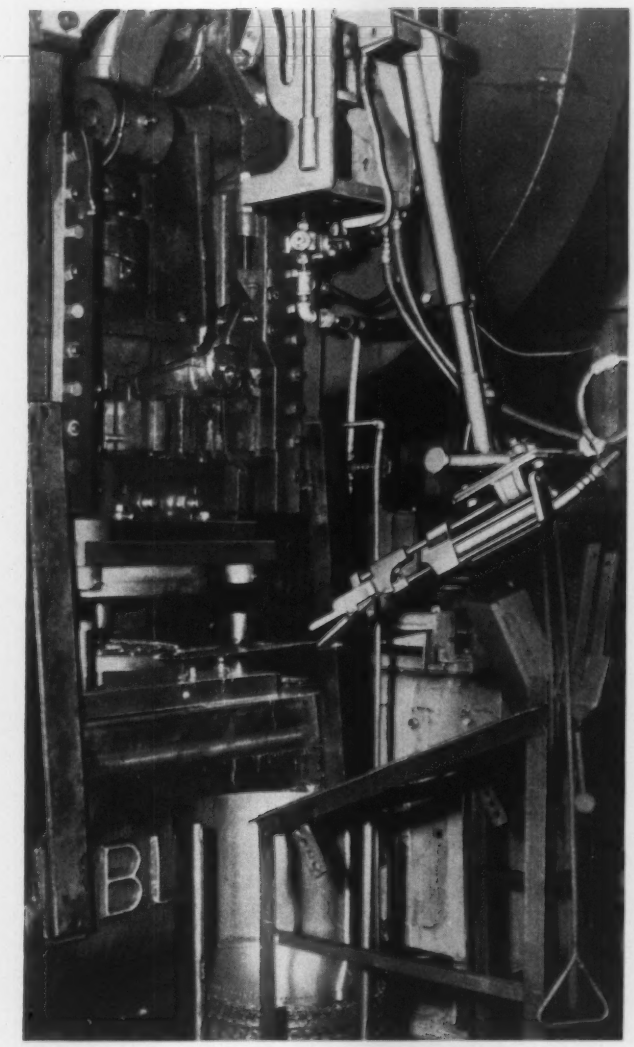
Fig. 2—(Right)—When this unloader was linked with a roll-feed mechanism, production of these "doughnut laminations" increased 500 per cent

By FRANCIS J. SEHN
Vice President
Sahlin Engineering Co.
Birmingham, Mich.



AUTOMATION OPENS

NEW VISTAS IN STAMPING



Automatic unloading can eliminate handling bottlenecks to help both large and small plants realize fully the high production capacities of presses

AUTOMATION IS STEADILY finding more and more favor throughout industry today. But nowhere has its application been more successful—or more logical—than in the handling of sheet metal parts, the production of which was generally already on an assembly line basis.

In leading automobile and appliance plants, assembly line production had been standard procedure. Conveyor belts, chutes and other equipment moved work from one press to another. But, for the most part, one or more operators were required for the actual loading and unloading. With the steady rise in labor costs, manufacturers began to look for some means of increasing manhour production and thereby set the stage for the introduction of automatic feeders, unloaders, turnover and transfer mechanisms.

Automatic feeding machines, generally conceded to have been among the first practical steps toward reducing these costs, popped up in various assembly lines. But these feeders were limited. They could

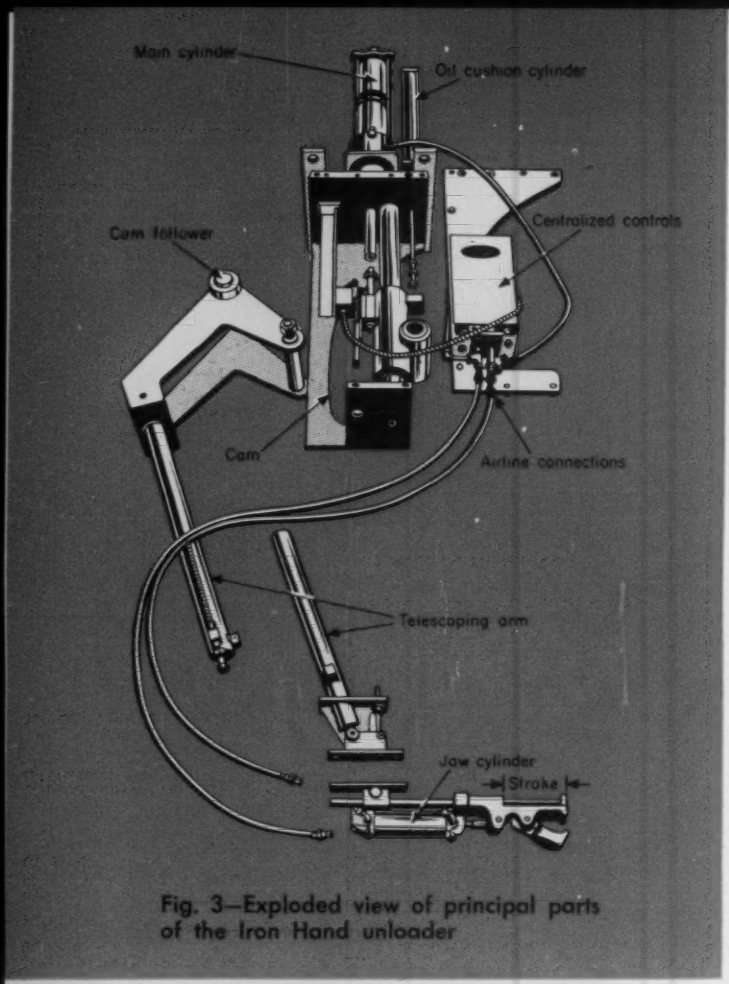


Fig. 3—Exploded view of principal parts of the Iron Hand unloader

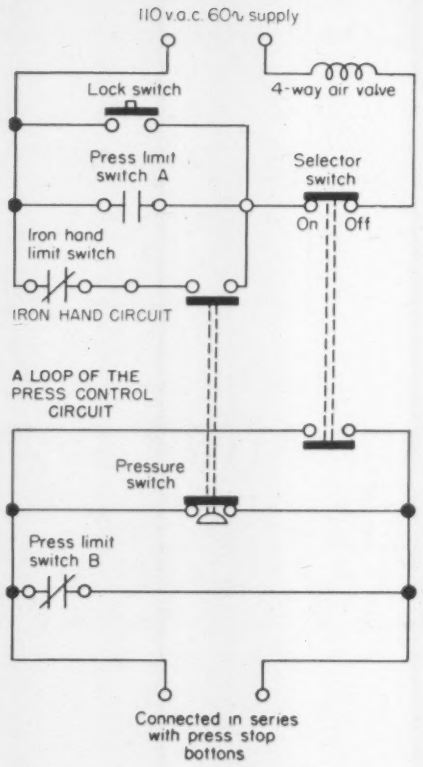


Fig. 4—Typical wiring diagram showing unloader circuit interlocked with press control circuit. Bar graphs shown at right indicate cycling sequence

load only as fast as parts could be unloaded; consequently, production was geared to machines that had to be unloaded manually. In fact, manual unloading was already becoming a bottleneck, *Fig.* 1, one of the slowest operations in a mechanized production line. Again engineers and production executives had to look for other cost cutters. This time they turned to automatic unloaders.

In the middle 1930's some solutions to the unloading problem began to appear when mechanical unloaders were introduced on assembly lines. Constructed for the most part by automobile plants, these unloaders represented a major investment in engineering, one in which considerable production value was necessary to make it worthwhile. These first unloaders usually had disadvantages. In addition to their cost, which was high, they were especially designed for each press, which limited their application. Also, they were cumbersome and bulky, and depended upon the press for driving power. Despite these conditions however, they did point the way to achieving success in several directions. They increased production, eliminated shop hazards and saved on manpower. Nevertheless, there was still a need for a low-cost, self-contained unloading machine versatile enough for application to many unloading problems. One of the men who recognized this need was Henry Sahlin, a former automobile production executive.

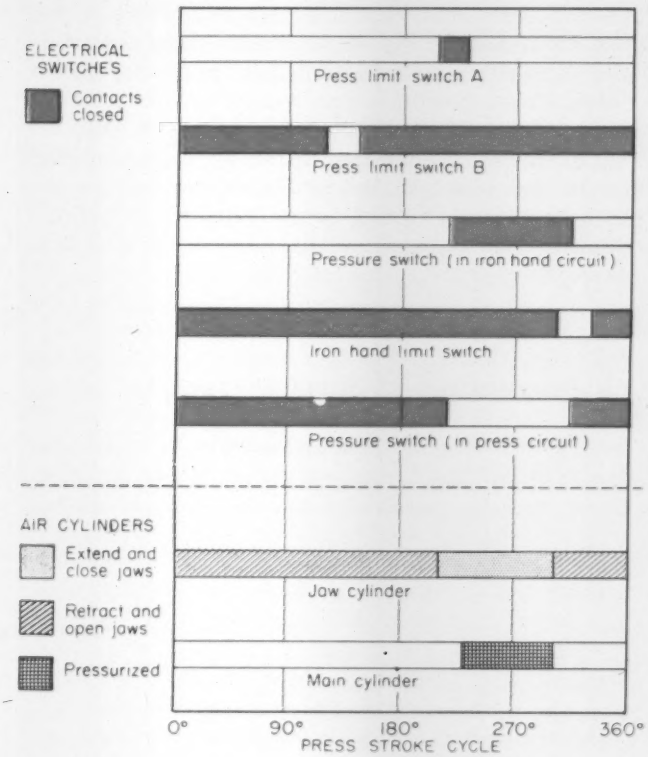
▶ First Self-Contained Iron Hand

In 1947, Henry Sahlin introduced the first commercially available self-contained automatic unloading machine for presses. The Iron Hand embodied numerous design features which made it adaptable to a variety of die conditions, unloading operations and press structures. Space and price requirements were also a major consideration in developing the new product.

The design features included adjustments on the jaw travel into a die. Depending upon the length of the telescoping arm, the distance a panel was carried out of a die was adjustable as was the angle of unloading. More than one panel could be unloaded at the same time by double mounting the jaws on a sigle arm. And the arm itself could be locked in the "up" position when setting up or working on dies.

As a result of the knowledge gained from the early installations, the Iron Hand underwent a continuous program of design improvements. These included standardization into four sizes for handling a variety of stampings and modification of the principle to meet different unloading conditions, *Fig.* 2.

Air operated and electrically controlled, the unloader is synchronized with the movement of the



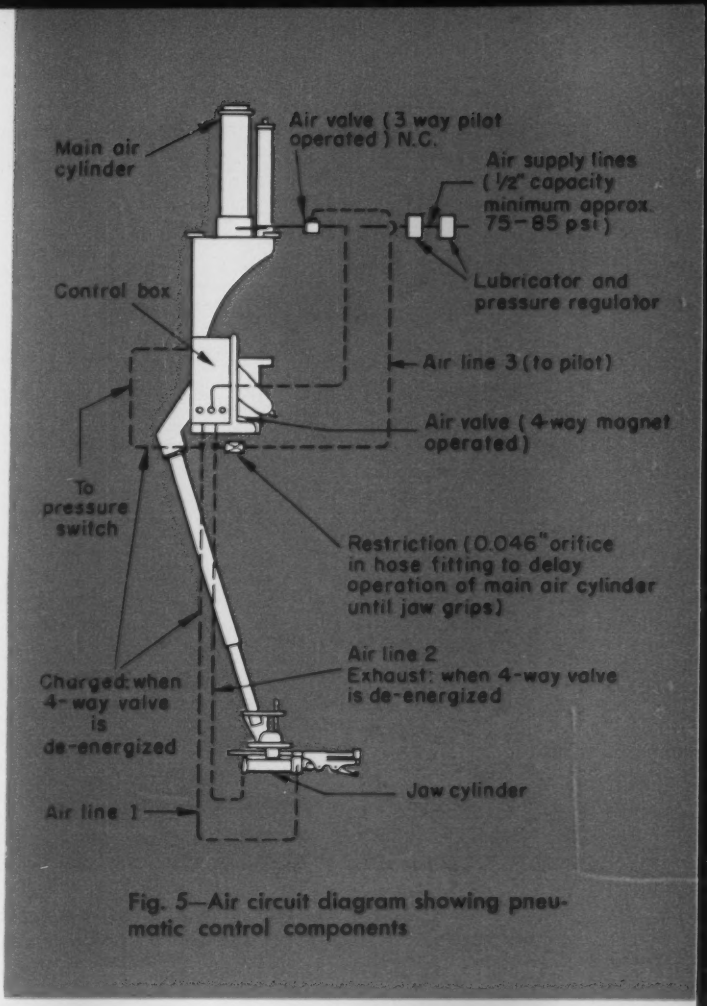

Main air cylinder
Air valve (3 way pilot operated) N.C.
Air supply lines (½" capacity minimum approx. 75–85 psi)
Lubricator and pressure regulator
Control box
Air line 3 (to pilot)
Air valve (4-way magnet operated)
To pressure switch
Restriction (0.046" orifice in hose fitting to delay operation of main air cylinder until jaw grips)
Air line 2
Exhaust: when 4-way valve is de-energized
Charged: when 4-way valve is de-energized
Jaw cylinder
Air line 1

Fig. 5—Air circuit diagram showing pneumatic control components

machine on which it is mounted. On a press, for example, when the press ram (slide) descends and completes its forming or blanking operation, the device begins its cycle. As soon as the ram begins to rise, the hand moves into the die and the jaws grip the stamping. When the slide has risen sufficiently, the stamping is lifted out of the die, swung clear of the press and placed on a conveyor or table. If required, stampings can be stacked or, when desirable, turned over for the next operation. After releasing the stamping, the hand returns to the waiting position for the beginning of another cycle.

The cycle time ranges from over 40 strokes per minute with the Junior model to approximately 20 per minute with the standard or large models. The unloader does not depend upon the press or any other machine for power. As shown in *Fig.* 3, the main power or lift cylinder raises the telescoping-type arm; a smaller cylinder opens and closes the jaws. An oil cylinder is also provided to cushion the overhead arm and control its speed. Less than ten minutes are needed to adjust the arrangements for unloading different types of stampings. And for convenience and safety, all adjustments are made at floor level, which removes the need for ladders and scaffolds, enabling the maintenance department to introduce new efficiency to productive maintenance programs.

▶ Simplified Electrical and Air Systems

The unloader is designed to operate on a 110-volt, 60-cycle circuit. It can be wired, however, to accommodate other types of circuits. A typical wiring diagram is shown in *Fig.* 4. In this figure the contacts are shown with the jaw back, the air valve de-energized and the mechanism at rest.

At approximately 6 inches past bottom center of the press stroke, the press limit switch *A* closes momentarily. This actuates the four-way air valve, *Figs.* 4 and 5, that reverses the pressure in the jaw cylinder and changes the contacts in the pressure switch which, in turn, holds the circuit closed while the hand starts its cycle. The jaw closes on the stamping; air bleeds through the orifice to the pilot of the three-way valve which opens line pressure to the main cylinder and the arm rises. Near the top of the press stroke, the Iron Hand limit switch opens, breaking the circuit and de-energizes the air valve which opens the jaws and exhausts the main cylinder. This places the pressure switch in its original position.

Press limit switches *A* and *B* are located in the press rotary cam switchbox. The lock switch is used to operate the Iron Hand without running the press. The selector switch permits running the press without cycling the unloader. As an added safety feature, the press limit switch *B* stops the

press if the pressure switch contacts are not in position shown in *Fig.* 4, thus indicating that the jaws did not retract, due to failure in the air lines.

Only three air lines are needed to operate the device. Two of these, airlines No. 1 and No. 2, *Fig.* 5, connect a four-way air valve in the control box to the jaw cylinder. A third, airline No. 3, connects the control box to the main air or lifting cylinder. The main air supply also feeds into the control box.

Development of Standard Jaws

Early Iron Hands were successful in automobile plants where they unloaded doors, hoods, quarter panels, window mountings etc. But, they could be

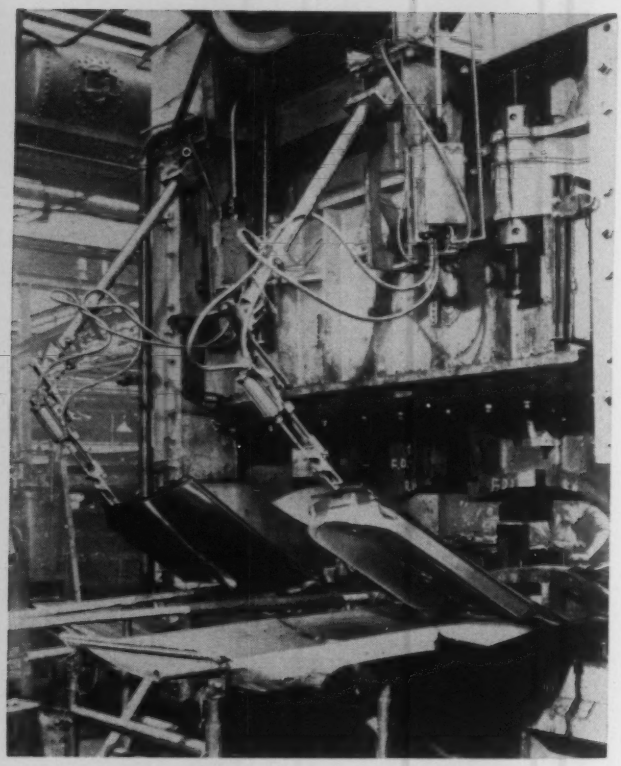
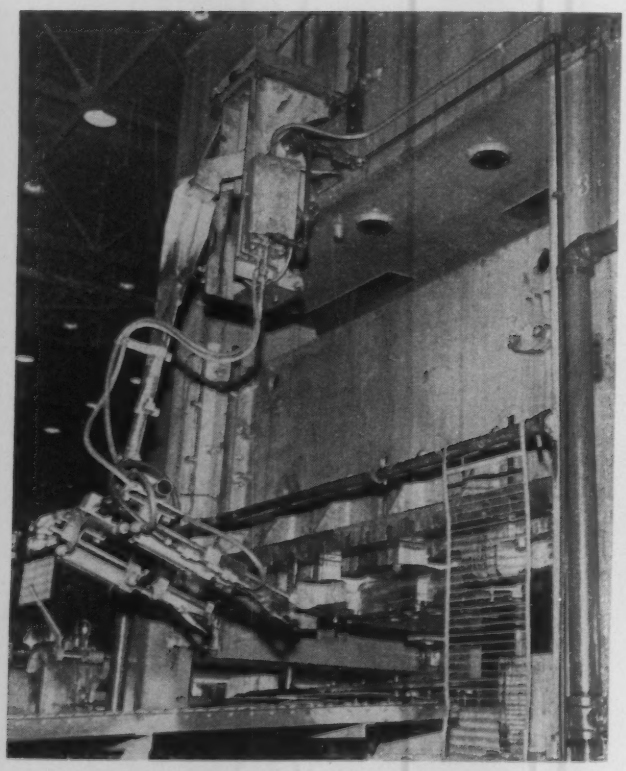


Fig. 6 (Left) At Vauxhall Motors, Ltd. inner and outer door panels are unloaded simultaneously by two independently-operated machines mounted on a single forming press

Fig. 7 (Right) Door panels and other large stampings are unloaded automatically at Nash Motors. The modified floating mechanism on the jaw assembly provides extra capacity for lifting the stamping vertically out of the die



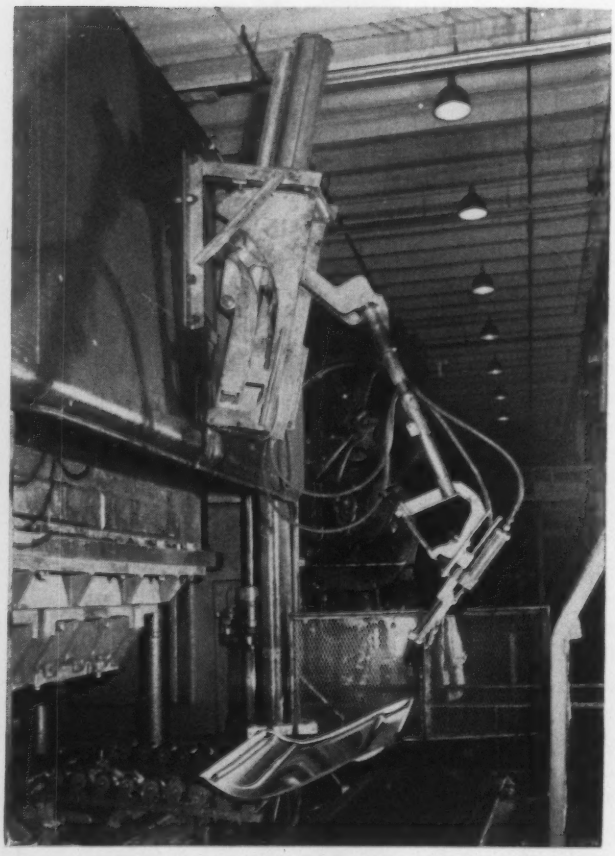


Fig. 8 (Left) Two blanks are unloaded with each press stroke by a twin jaw assembly that is mounted on a single arm

more valuable as a production tool, manufacturers and engineers implied, if they were applicable to a wide range of unloading operations. For one thing, this meant designing several jaw assemblies that would grip such stampings as bumpers, fenders and irregular shapes. Furthermore, thought Sahlin engineers, was it not possible to adapt these principles to a variety of unloading conditions? In answer to these queries, a research and development program was instituted. *Fig.* 6 through *Fig.* 9 illustrate various applications that have been successfully installed.

Gradually different types of metal jaws were developed to handle a variety of parts which are formed by the medium and large-size presses in the domestic appliance and automotive fields. The six jaw types in greatest use are the standard, vise, chisel, hook, pivot, neoprene and the confined as illustrated in *Fig.* 10.

Standard Vise: The original jaw design, this type still applies to a majority of stampings regardless of shape, size or weight. It grips panels having a minimum of two inches clearance from the lower dies, as in the case of drawn stampings that are lifted two or more inches from the draw ring. This jaw has four vise grippers, two each on the upper and lower jaw sections.

Chisel: The chisel jaw, together with the vise, is applicable to 75 per cent of press unloading jobs. It is recommended for stampings that are not lifted off the lower die. The lower jaw is a chisel blade that scrapes the panel from the die surface. The upper jaw has two cone-point grippers. This jaw, however, can also be used to unload stampings which are lifted off the die.

Hook: Developed for stampings that lack a gripping surface, the hook jaw utilizes a hole or pierced section to lift the stamping out of the die. Barrel heads and channel-shaped panels fit into this category. The lower jaw of this type is designed to suit the panel to be removed.

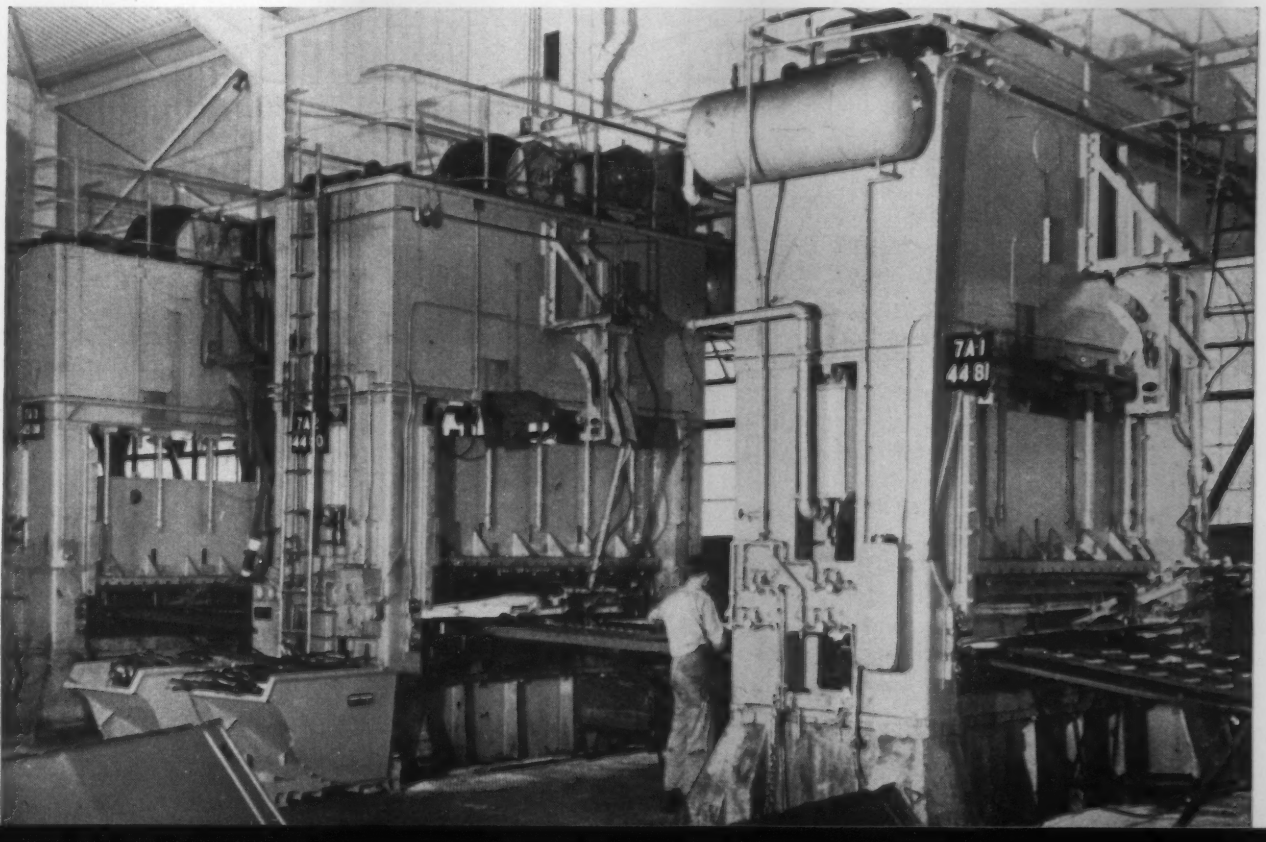
Pivot: Jaws unload stampings where die clearance is facilitated by pivoting the panel free. Some automotive front fender presses and die setups call for this type of jaw. Pivoting is also desirable where there are succeeding operations. The jaw has a single cone-point gripper on each of the upper and lower jaws.

Neoprene: Jaw unloads finished stampings that must be free of abrasions and indentations such as window and garnish moldings. The upper jaw is neoprene tipped and keeps parts unmarred: the lower jaw confines rather than grips the stampings.

Confined Type: This type removes stampings with a vertical flange. Designed to the dimensions of the flange, it contains rather than grips the stampings. Flanges are not crushed nor are the stampings marked. It is applicable only where the stampings are lifted at least two inches off the lower die surface.

Another variation of the basic unit which added to its versatility was the floating mechanism, shown in *Fig.* 11. This mechanism facilitated the unloading of large panels that had to be lifted ver-

Fig. 9—Automatic unloading makes possible more efficient utilization of presses in production line. Whirlpool Corp. employs this arrangement to fabricate 51-pound cabinet blanks



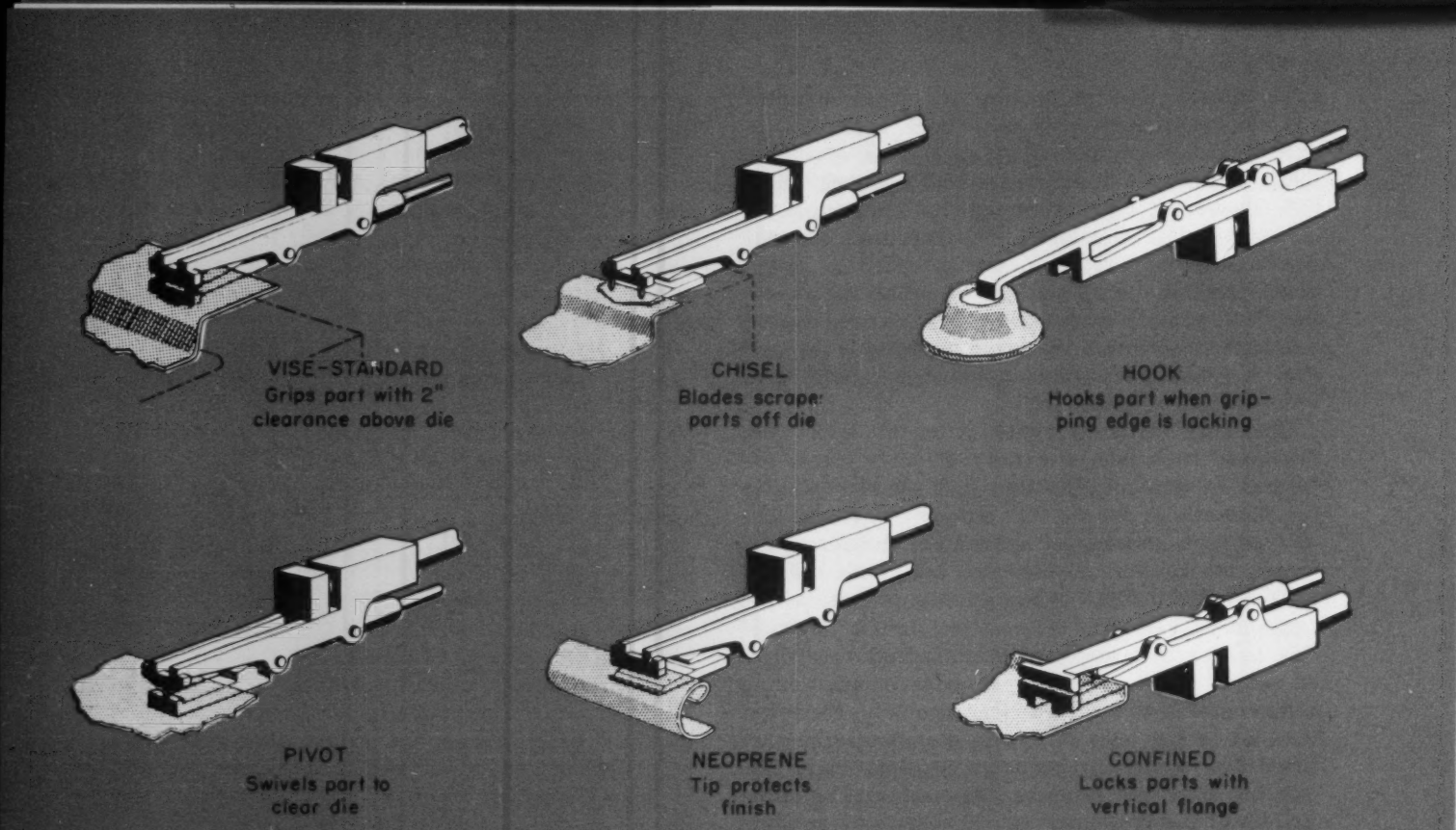


Fig. 10—Group of standard jaw types which enables the basic device to unload a variety of stampings

tically out of the die more than eight inches and for which no provision was made in die design.

A normal four to eight inches vertical travel is supplied by the standard model. The floating mechanism, however, provides as much as 12 inches additional vertical lift to the jaw, enabling it to raise the panel clear of the die before beginning the outward swing. This is accomplished by pivoting the jaw assembly at the back, as shown in *Fig.* 11, and raising it by means of an air cylinder mounted above the jaw assembly. As soon as the panel is gripped, it is raised a predetermined distance (up to 20 inches) before it is pulled from the press.

A modification to the Iron Hand mounting arrangement facilitates installation of the machine. Units are supplied with specially-shaped side plates which hook onto the cross bars of a bracket that is permanently attached to the top of the press. The mounting is fastened and locked at one point only. Holes in the side plates facilitate lifting by crane for quick transfer from one press to another. This design enables unloaders to be kept in service elsewhere while presses are down for repairs or for die changeover.

▶ Adapting Principle to Other Uses

As a companion to the overhead arm type of automatic unloader, Sahlin introduced a portable floor-type unloader. This machine, which is wheeled up to small and medium-size presses for removing small parts, consists of the same jaw, cylinder and electric control assemblies used with a different arm design. This unloader is adjustable up and down to reach various die levels and can be set at any angle required. As *Fig.* 12 shows, jaw travel is straight line, reciprocating motion, especially suited for the removal of small parts at high speed. Due to its portability, safety features and high speed, the portable unloader is recommended on applications where it is otherwise impractical to eject parts mechanically, through a bed opening or by gravity.

The portable unloader is mounted on a steel frame which rides on four caster-type wheels. A built-in locking device is provided. The machine is suited to short run job shop work; because it is mobile it can be kept in continuous service by moving from one press to another, providing much asked for job shop automation.

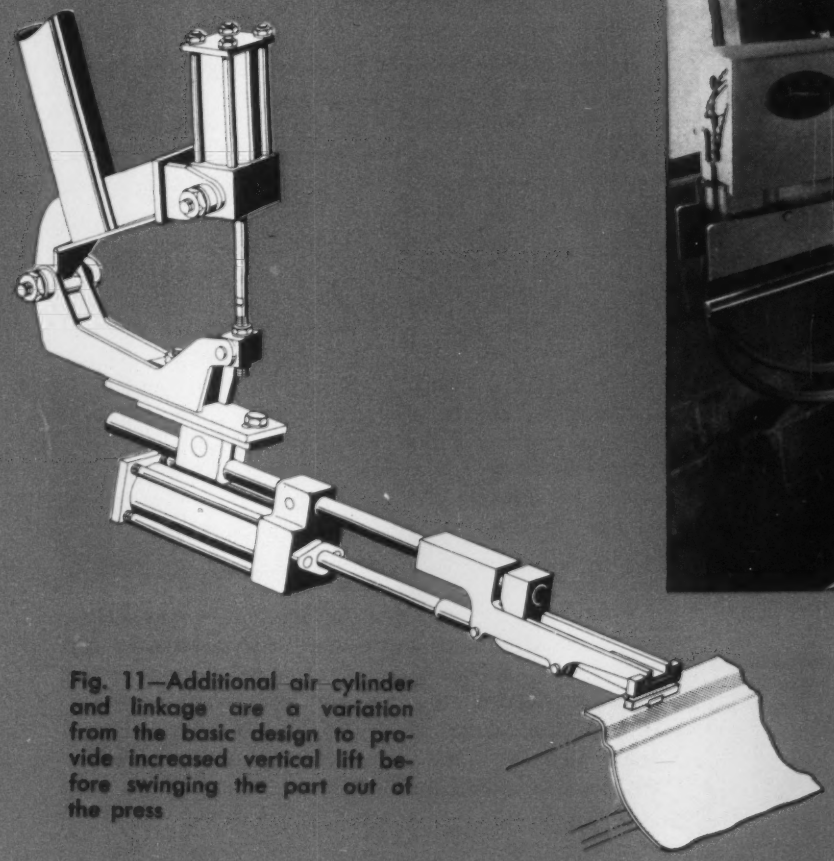


Fig. 11—Additional air cylinder and linkage are a variation from the basic design to provide increased vertical lift before swinging the part out of the press

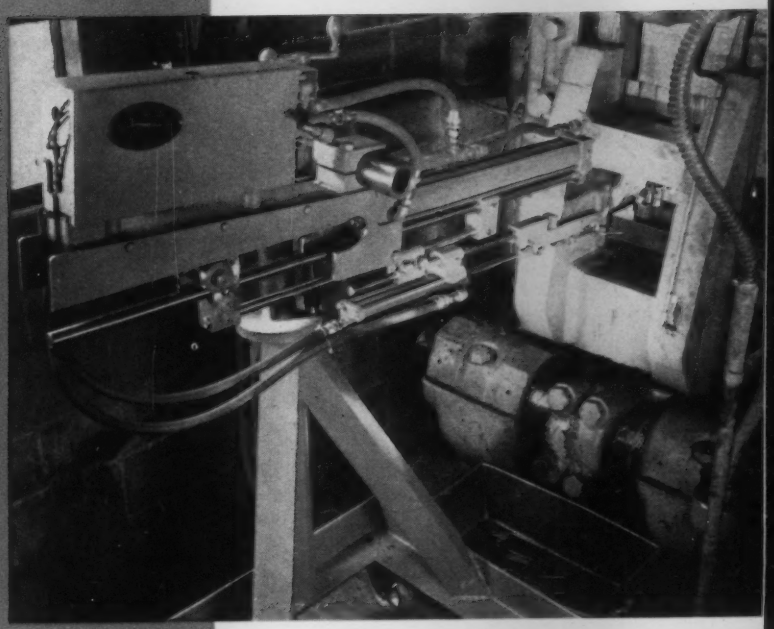


Fig. 12—Floor type unloader on wheels suited for job shop use on small and medium size presses

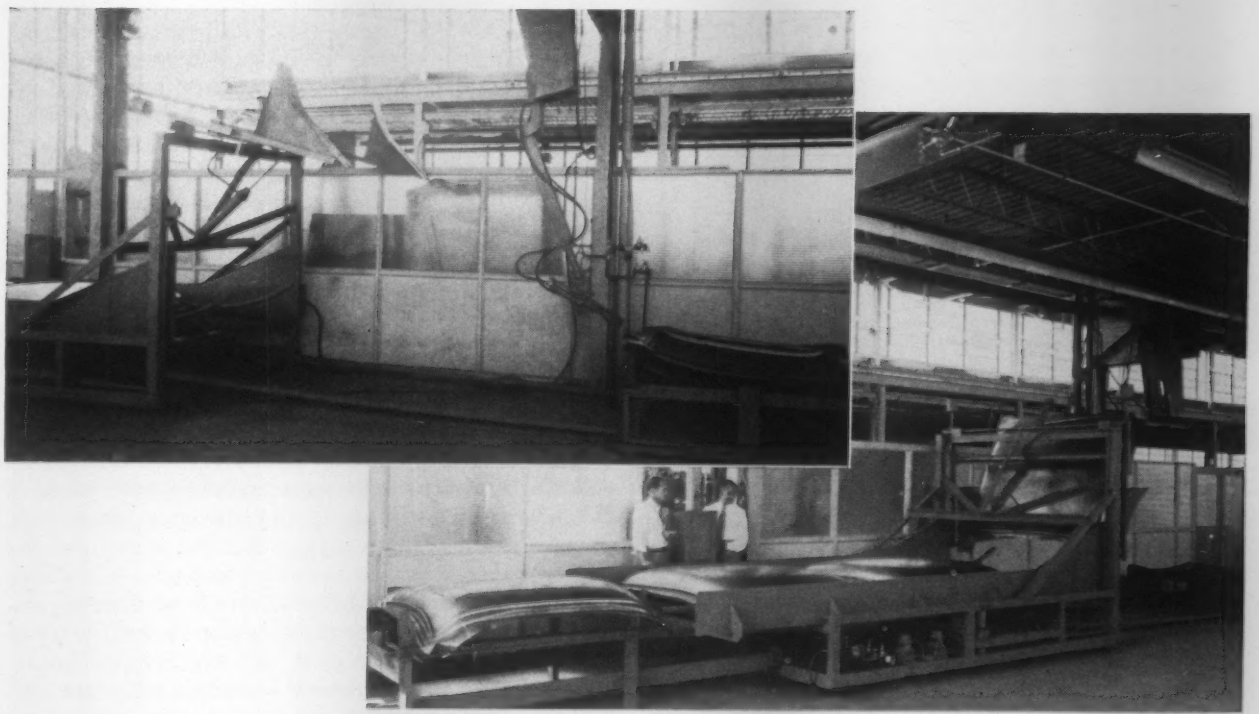


Fig. 13—Tryout setup of unloading, turnover, transfer, and feeding mechanism designed to move parts between presses. Station at right represents draw die. Hand moves part to turnover basket which feeds trimming press preload station

When the ram descends and completes the forming or shearing operation, the steel jaw moves into the die and takes its grip on the stamping. The moment the ram rises sufficiently, the jaw lifts the stamping, moves back out of the die, and drops the stamping in a tote box or on a conveyor. It then returns to its original position to await the next cycle. Here, as with the overhead arm, any one of the standard jaw types can be used.

Automation engineers are finding that their field of operation offers many opportunities to apply proved principles and practical automatic cycling devices to a wide array of uses. This basic floor model has been altered for use as a loader for feeding parts to machinery, rearranged as an unloader for die casting and plastic molding machines, and adapted to shovel-type transfer feeders and unloaders that process parts through presses.

THE AUTHOR

FRANCIS J. SEHN, vice president, Sahlin Engineering Co. has spent most of his business life in and around Detroit's assembly lines. He got his start in industry as a tool and die trainee with the Fisher Body Division of General Motors Corp. and later became chief die engineer for the Tank Division during World War II. A registered engineer, he served as representative in the Detroit area for E. W. Bliss Co. and then for Clearing Machine Corp. During this period, much of his time was spent in the major automotive plants, working with production executives in the planning of high production press lines.

Now, as vice president of Sahlin Engineering Co., Mr. Sehn is active on new frontiers of press line automation. He reports an ever-increasing interest on the part of all industry to bring the most out of its press lines by loading, unloading and transferring material automatically.

Mr. Sehn is a member of the Engineering Society of Detroit, the Society of Automotive Engineers, chairman of the National Book Committee of the American Society of Tool Engineers and a member of the Honor Awards Committee for the Pressed Metal Institute.

▶ Part Movement Between Presses

A recent development program was undertaken to solve the problem of moving a stamping into the next press automatically after it has been unloaded. After nine months of design and prototype work, a new transfer assembly was tested satisfactorily.

With the new machine, finished panels move through the tranfer assembly on their "undersides" without touching any finished surfaces. Moreover, transfer operations are positive in that the panels are held and controlled at all times throughout the cycle.

Shown by the tryout setup, *Fig.* 13, an unloader grips a hood panel in the forming press. As the press ram rises the arm picks the panel out of the press. At the top of the arc, the hand releases the panel, top side up, into a cradle of the transfer mechanism where it is transferred to the preload station.

This transfer machine is light in construction, easily installed, and accessible for maintenance and lubrication. It can also be removed quickly when space is needed to repair or service the presses. In addition, these machines are adaptable to almost any type of unloading, transfer, turnover and feeding conditions.

▶ Speed Output—Cut Accidents

Mechanical unloaders, turnover, transfer and feeding machines have been a boon to the automotive and domestic appliance industries. Users have found that they have accomplished four things.

Production has increased. The percentage of increase depends largely upon the degree of press capacity that was utilized with manual unloading. If, for example, a press capable of 20 strokes per minute delivered only 8 parts a minute, obviously 60 per cent of its productive capacity was wasted. Moreover, automatic unloading eliminated such production retarding factors as operator fatigue, absenteeism and safety hazards.

Accidents decreased. When these unloading mechanisms replaced manual handling, pressroom accident records began to decrease. In many plants, Iron Hand installations were the direct result of recommendations by the safety engineer.

Manpower savings were gained. Here again the degree of savings varies with the particular application. In the case of an automobile roof panel—often weighing up to 80 pounds—four men were formerly required to accomplish the awkward unloading operation. In smaller installations, a single unloader eliminates the need for hand feeding entirely or permits a single operator to feed a press more rapidly.

And labor has no quarrel with this advancement. Labor unions usually welcome the machines that take the backache out of the stamping shop, remove the need of handling sharp-edged pieces and minimize many saftey hazards.

1 Overall view of the two egg handling machines installed side by side. Six candler's stations per machine each receive cases of unsorted eggs on platforms at left. Candler makes quality selection and places egg into machine where it is weighed and proceeds on conveyor (right to left) from candling station through shell protecting to packaging.

AUTOMATION TODAY

MODERN EGG HANDLING

MARKETING OF EGGS in the USA, 1954, involves sorting into classifications of quality and size so that the customer can be assured he is getting what he wants and is paying for. Packing plants do not put all their eggs in one basket. To bring automation into the solution of problems of sizing, sorting, shell protecting, counting, and packaging eggs, the Packing Equipment Div. of Food Machinery and Chemical Corp. designed and builds an installation capable of automatically handling 270 eggs a minute.

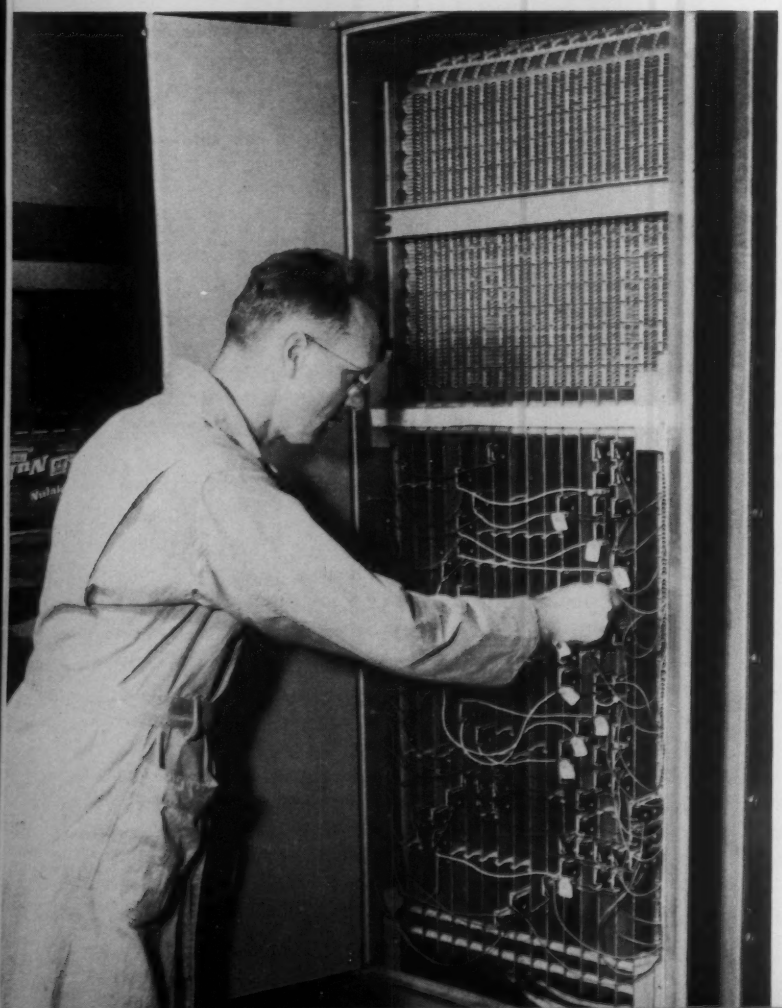
Candlers manually remove the eggs from the incoming cases and visually sort each egg into its quality-grade. Candled eggs are placed in one of eight racks designated to correspond with the grade classifications. The machine takes over and does the rest of the job. An automatic weighing station assigns one of six size categories to each egg, and the egg moves onto a conveyor cup to be transported through a coating spray station to packaging.

To keep track of these sorting operations, a memory system is employed. Using signals received from the first sorting racks and the weigher, the memory device knows the quality-grade and weight of each egg that is in each cup on the conveyor at any given moment. Six sizes and eight grades make a total of 48 classifications. This information is read out of the memory system for three purposes: control of the protective spray station; provide data for output, inventory and printing counters; and to control the delivery of the eggs at the proper packaging station.

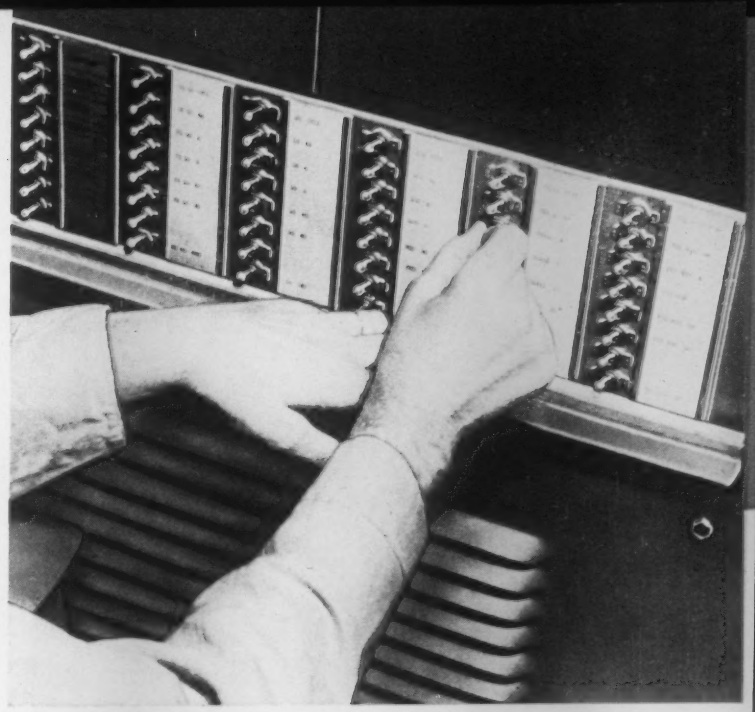
The packaging area has stations for loading trays and dozen-size cartons which are automatically fed to the loading position. When an egg reaches the appropriate station a selector switch automatically opens the conveyor cup and the egg is deposited into a waiting carton or tray. An attendant places full trays into cases but the cartons move automatically to take-away conveyors through an automatic carton closer and code-dater to a station where they are placed in cases.

Two of these units have been installed at the Modesto, Calif. branch plant of the Poultry Producers of Central California. Photos show the principal features of this installation.

2 Shuffle feeder racks at the candler's station provide for eight selections. This company sorts into seven groups: *AA*, *A* white, *A* brown, checks, *B*, heavy dirty, and light bloods. Feeders index once a second and transfer eggs to the vertical elevator which takes them to the weighing station whose scale is accurate to a tolerance of one gram. The egg passes over a counter switch where it is tallied into the producers lot by size and quality, and then goes under a marking wheel that codes it with invisible ink. When a producers lot is finished, a ticket is inserted in the box, (lower right) the button pushed and the tabulation by grade and size is automatically printed.

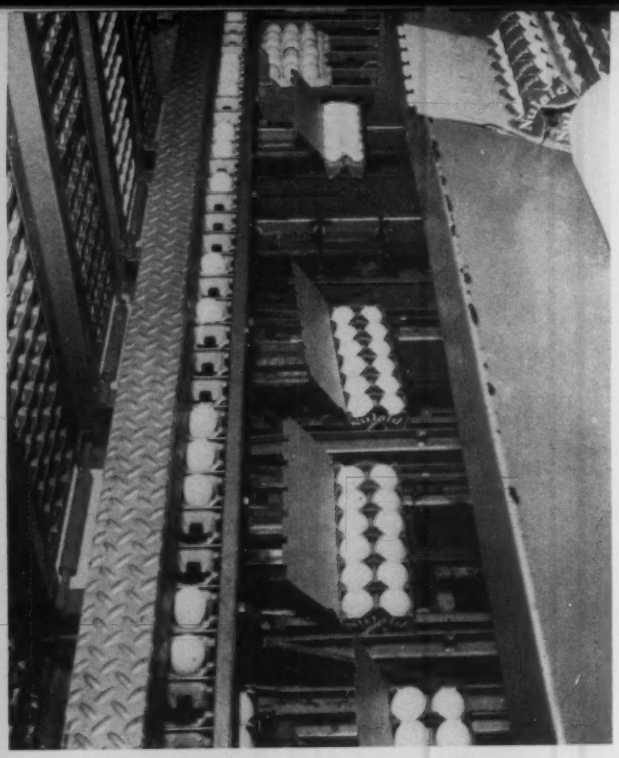


3 Weight classifications are: jumbo, extra large, large, medium, small, and peewee. As soon as an egg is weighed an impulse is sent to the memory system which has previously received the quality signal from the shuffle feeder. Eggs from all six candler stations deliver to a single line conveyor so must be accelerated by a feeder wheel to a speed six times that of the elevators in order that they may be transferred into an empty conveyor cup. The memory device shown is adjusted to control the release of predetermined classes of eggs at the selected packaging station. Unit provides for conversion of any size and quality combination to another packaging station without interrupting the machine.



4 Shell protecting is done from an arc of seven jets mounted at right angles to the main conveyor line. Jets are in action for approximately 1/12-second as the egg passes under the arc. Plant supervision may select any or all of the 48 possible classifications to get this treatment by positioning the 48 toggle switches on the memory unit panel. Memory unit actuates the spray unit only when cups with the classifications chosen are in the coating zone. Shell protection is thus obtained automatically without extra handling.

5 Conveyor line moves eggs into packaging area where there are 12 stations for loading trays and six stations for dozen-size cartons. The settings in the memory device have determined which station is to receive which classifications of eggs. When an egg reaches its apropriate station, a selector switch automatically opens the conveyor cup and the egg is rapidly but gently deposited into its proper place in the carton or tray. Attendant places trays in cases.



6

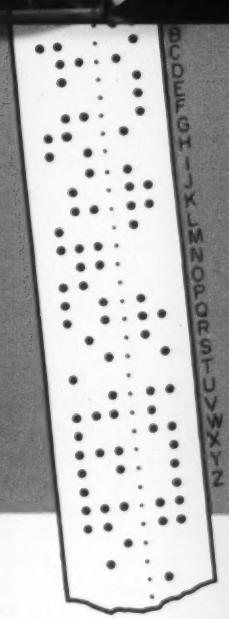
The memory device moves the carton, row by row, discharging it when full, and replacing a new package without delaying the delivery conveyor. Here eggs are shown coming down the line. Vertical cartridges of cartons are on the left. Empty's are fed across underneath the line and off to the right to the automatic carton closer and code-dater.

7

One attendant operates the carton setup machines and keeps the carton chutes and tray holders filled with a reserve supply of empty packages for both lines at the Modesto installation.

8

Filled cases move by automatic conveyor to closer and sealer. Both top and bottom is glued and sealed and case is coded with date of packing. Photoelectric controls separate half-cases from 30-dozen wooden cases as they move down the lines, diverting them to their respective positions. These "eyes" also delay cases moving in from the different lines to prevent their colliding as they move past the intersections.



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Five-channel punched tape has been preferred as the common language because it has been standard in the communications field. Therefore, no translation problem exists in either centralized or decentralized data processing with regard to data transmission.

INTEGRATED DATA PROCESSING BRINGS

AUTOMATION IN PAPERWORK

By P. B. GARROTT
Director of Market Development
Standard Register Co., Dayton, Ohio

Modern enterprise is founded on and functions around basic business information of tremendous scope. Realization of success and profitable operation depends mightily on speedy access to complete and accurate data. Automation of these paperwork operations — recording, transmitting and reuse of daily business information—offers an economic solution suited for immediate and future needs. In this article, first of a series by P. B. Garrott an eminent authority, this new philosophy and plan is outlined in detail along with the equipment developed by numerous companies for accomplishing necessary operations automatically in a fully integrated process.

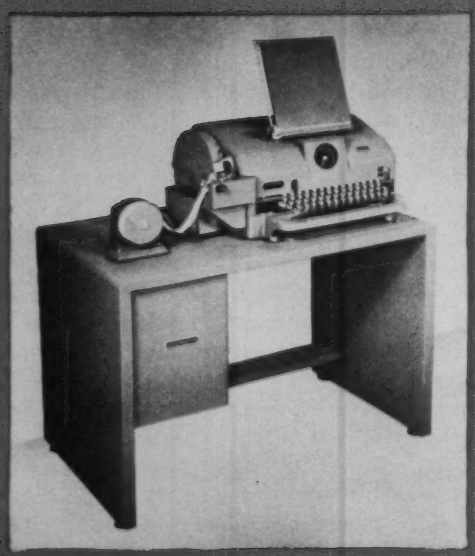
PENDING ACHIEVEMENT of the ultimate in automation, business and industry must continue to rely upon the unreliable human element at many key operational points. Paperwork forms the basis of management control over those people. Paperwork failures result in expensive deviations from management plans. Superb operating facilities are robbed of full efficiency when operating instructions are late or wrong. These instructions are late or wrong because facilities for processing them are relatively antiquated and inadequate. Ability to provide proper infromation may be balanced with the need for such information by applying automation principles to paperwork. Integrated data processing offers one practical plan.

Reduced to barest essentials, most management problems come down to a single, frustrating element—the unpredictability of people. At nearly every key point in business or industrial operation where an intricate step must be performed or a vital decision made and acted upon, some member of the human race is likely to be found. Certainly, that man has been given tools and instruments and machines to help him to function according to plan—but will he do it?

It is the imponderability of this question, sharpened by painful memory of cases where he didn't do

Incoming orders received on five-channel tape are retransmitted by tape from the Dow Chemical Co. communications center. Regional offices write orders on a Teletype which produces a transmission tape to transmit the orders to the center. Once received in the five-channel language, the tapes can be used in central office machines for data processing.

INTEGRATED DATA EQUIPMENT



Teletypesetter, used in the communications field to perforate tape for telegraphic transmission, may also be used to punch coded tape for any common language machine. An experienced typist can quickly learn to operate this tape punching device designed by the Teletype Corp.

Flexowriters, manufactured by Commercial Controls Corp., produce original typed documents and by-product punched tape with selected information to actuate the same or other Flexowriters, address plate embossing machines, punched card machines, communications machines, data processors or any other unit actuated by punched paper tape. These electric typewriters read punched paper tape, produce printed documents and by-product tapes. Punched tape prepared by data processors, office machines, recording instruments, communications equipment, other Flexowriters or any other unit that punches tape, may be translated into printing.

it, that gives management people their ulcers and high blood pressure. No doubt that's why management looks so hopefully at the idea of automation. They see, at long last, the prospect of reducing the human question mark to endurable proportions.

Logically, some practical balance must be maintained between efforts to achieve automation and efforts to keep business body-and-soul together. Within one limited area, possibly both "birds may be killed with the same stone." This area is generally referred to as paperwork—or to be more exact, "that ——— paperwork."

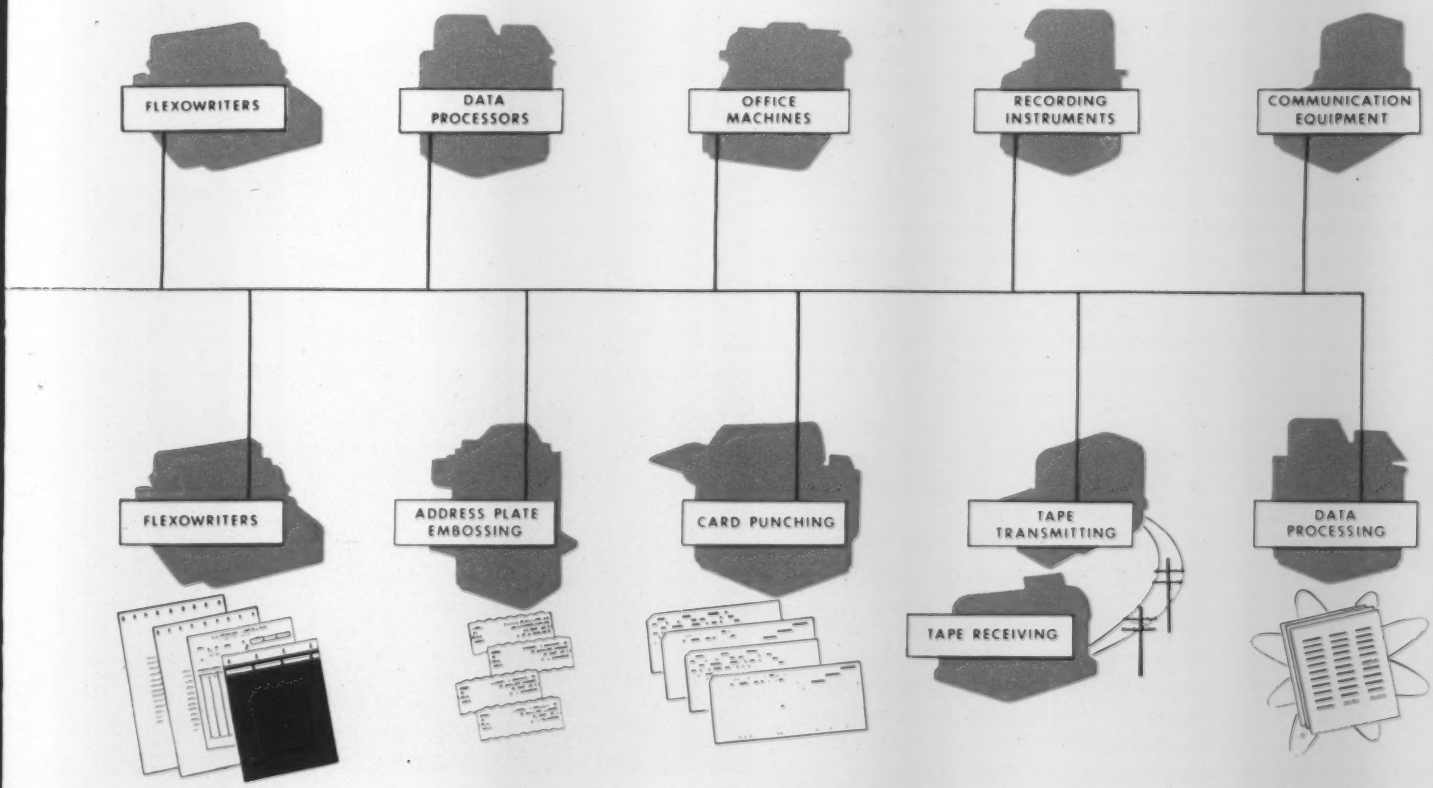
▶ A Solution for Progress

Many pat answers are given to the question, "Why all this paperwork?" The real answer goes back to the earlier analysis of management's biggest problem—the human element. If there were no people in business operations, there would be no need for paperwork. But as long as we must depend upon people to control and execute key operations, we must give them written instructions and directions. Sounds simple, doesn't it? In principle it is, but in practice maintenance of adequate systems of human control, through paperwork, may devour ten per cent or more of the sales dollar. And paperwork and people will be essential factors in business operation for a long time to come.

How can the burden of paperwork be reduced and at the same time progress be made toward ultimate automation? Simply by reducing paperwork to its barest essentials, then mechanizing those essentials to the greatest practical extent. To illustrate one means by which this process may be achieved, consider the paperwork simplification philosophy represented by *integrated data processing.*

This catchy-sounding phrase refers to an idea which was introduced to about 1700 business men during an American Management Association conference last February. Since that time the idea has spread through a major segment of the business world. It has been the subject of many talks before business groups and has struck a responsive chord in a surprisingly high percentage of those to whom it was presented.

Integrated data processing is not an entirely new creation, but rather is one of those highly valuable innovations combining elements of several existing ideas into a new, more effective pattern. It might be described fairly as a plan for mechanizing the recording, transmitting and reuse of necessary business information. Integrated data processing, in other words, is a plan for mechanizing business paperwork. One of its prime purposes is to reduce the danger of human failures by reducing the degree of direct human participation in the processing of vital business informa-



tion. Another is to provide that information wherever it is needed, and in the form it is needed—more quickly.

Eliminating Duplication of Data

In the average business, an amazing amount of paperwork duplication occurs daily. As a simple example, consider the situation wherein the supply of a purchased part or unit is found to be at or below the low limit. To replenish that stock, an inventory control clerk will write a purchase requisition authorizing the purchasing department to procure additional stock. The purchasing department may issue invitations to bid or requests for quotation to several eligible suppliers in the process of selecting the most desirable source. Once a supplier has been selected, the job will be awarded to him in the form of a purchase order. Later, after the order has been filled and shipped, the buyer's receiving department will record the arrival of those parts by preparing a receiving report. In essence, this description of events in a basic business operation will be recognized as typical of industrial operation in the limited area involved.

There's a lot of paperwork represented in this simple series of steps. Literally millions of purchase requisitions, requests for quotation, purchase orders, and receiving reports are being written daily by American business. Few realize the tremendous amount of duplication involved in even this simple series of events, hence the blood-sucking extra costs involved are too often overlooked. Paperwork duplication involved in this example becomes apparent when attention is focused upon the basic information which forms the heart of every one of those related paperwork steps. The requisition—which started this chain-reaction—was written to include such obvious things as the part number, description, quantity needed, date needed, point of delivery.

Those same essential facts were repeated upon each of several requests for quotation, and again on the resulting purchase order, and again upon receiving reports. Half-a-dozen different records, and half-a-dozen clerical transcriptions of the same basic, common data are not unusual to such operations, and similar duplication extends through all business paperwork in general.

Now, obviously, this is not needless duplication. That same basic information, in written form, is necessary at every step of the example, to tell the people at each point what they are dealing with and what they are expected to do about it. The needless waste occurs as a result of the means used to prepare and deliver necessary facts to those key people. In ordinary practice it's probable that the preceding simple example would involve the writing, rewriting, copying or transcription of the basic facts by at least six different people. It's that old human element in the job that causes the unnecessary waste and trouble, in the form of lost time, errors, high costs, and low production.

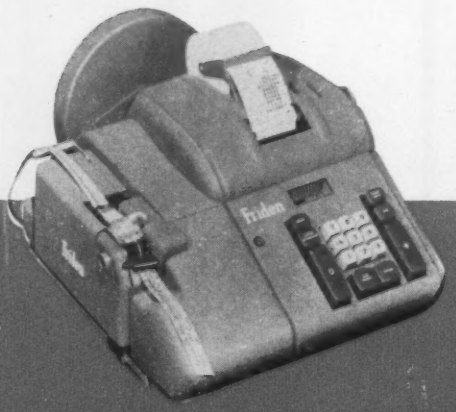
Integration With Punched Tape

Integrated data processing offers a means for mechanizing the processing of necessary repetitive information, through use of what has been called the "common language" tape. The term will occur frequently in any discussion of integrated data processing, so let's define it.

The principle of programming or controlling machine operations through use of code-punched holes in paper tape is not new. Player pianos, type casting machines, and wire communications machines are three familiar examples of the application of this principle in three widely different fields. In each case, the position of a hole, or combination of holes, is detected and interpreted by some sort of reading mechanism, causing a preselected operation to be performed. Coded holes are read sequentially as paper tape is moved across the reading position.

Obviously the manufacturer of player-piano rolls wished only to convert his code-holes into notes and

INTEGRATED DATA EQUIPMENT



As items are printed, or printed and added on a standard adding machine tape, selected data may be automatically punched on a five-channel coded tape. From this Add-Punch Machine by Friden Calculating Machine Co., the code tape may be sent directly to a card-punch machine, by-passing the intermediate operations of punching and verifying cards and copying of original data. The tape may be interpreted by any machine equipped with a tape read-out mechanism such as typewriters, bookkeeping or communications machines.

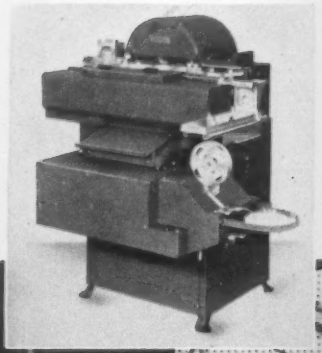
chords from a piano. No one in his right mind ever expected to run a player-piano roll through a type caster in order to set that musical selection in metal type for example. In other words, each of these punched paper tapes was a coded form of one single native language. Player-piano tapes were intelligible only to player-pianos; type-caster tapes were intended for exclusive use by type casters and so on. Each type of machine dealt with a different kind of information, and each employed the same basic principle of code-punched paper tapes to mechanize its operation.

Integrated data processing concepts provide that the same principle be used to mechanize the processing of business information. In business operation, information is handled by means of what are generally called office machines, of which there are many types. Each type has its own native language, too. The common typewriter, for example, reacts only to the physical depression of one of its keys by a human hand. The keystroke is its native language and it understands no other. Similarly, punched card accounting machines react only to the presence of a hole in a card and are not equipped to recognize the key-stroke language of the typewriter.

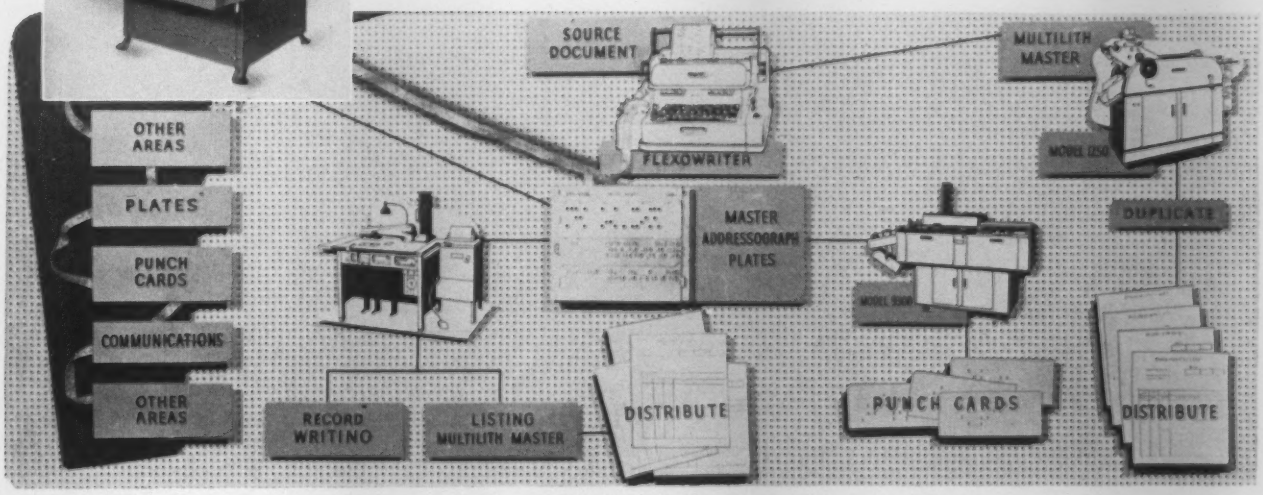
Nevertheless, in processing business facts, a variety of office machines may be involved. Referring again to the stock-ordering example, the purchase requisition might well be a handwritten document; requests for quotation would probably be typewritten; and the purchase order might be produced through use of punched card accounting machines. Yet, as we've recognized earlier, all these documents are referring to the same transaction and must present the same basic information about the material needed.

Lacking some more practical way to translate this message from handwritten to typewritten to punched card form, a human operator must be depended upon. Integrated data processing, however, provides means for making such translations mechanically and automatically by use of the punched paper tape principle, and with a group of office machines all capable of reading and using the same coded paper tape.

Common language tape is one which has been punched in conformance with the long-used five-channel communications code. "Five-channel " simply means that there are five positions across the 11/16-inch width of the tape in which a code hole may be punched. A single hole punched into the top "channel" always represents the letter E or its upper-case equivalent, the figure 3. Single holes in other positions, or various combinations of two or more holes, are used to represent all



Automatic Graphotype machines, product of Addressograph-Multigraph, are controlled by perforated tapes prepared on a Flexowriter or Teletypesetter. The original tape can be used to create as many duplicate Addressograph plate files as required. It is also possible to create from a single tape, two plate lists that differ as to amount of information carried. In such cases, all information perforated into the tape is embossed on one list but only part of it embossed on the other.



other characters and figures in similar fashion. This is exactly the same code system which has been used for many years in the automatic operation of Teletypewriters and related equipment. Borrowed from the communications field, it's obvious that common language tape can be read and used by communications equipment, since it is also the Teletypewriter's native language.

▶ Common Language Equipment

While this equipment serves vital needs in processing business information, several other types of equipment are also in common use. These other types of machines are equally able to read and use common language tape.

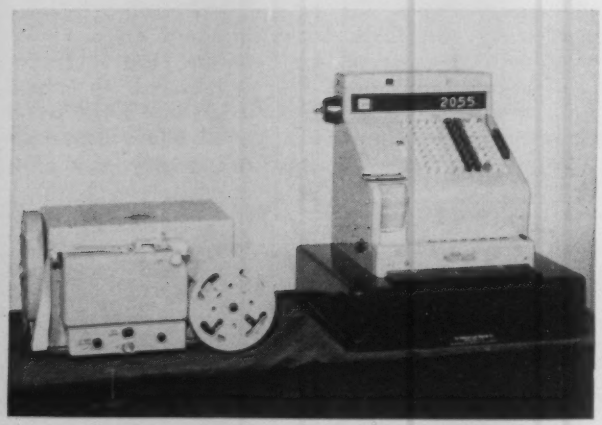
Perhaps the most familiar office machine is the typewriter. There now exists one kind of electric typewriter which is equipped with tape-punching and tape-reading units capable of making and reading common language tapes. This machine may be operated much like any other electric typewriter by manual depression of the keys. At the same time, however, this typewriter can produce a punched paper tape into which has been coded the same information that was typed upon a document in the regular manner. Automatic punching of by-product tape takes place simultaneously with operation of the keyboard. Speed of both operations is limited only by the typist's own ability. This is another way in which repetitive information may be stored in mechanical form for later reuse.

Further, the tape reading unit of this machine can accept and read any common language tape, operating the typewriter automatically to type that coded information at high speed. Thus, a common language tape made earlier either by teletypewriter equipment or by another of these tape-punching typewriters, could be used to recreate repetitive information without danger of human errors in transcription and at speeds in excess of manual operation.

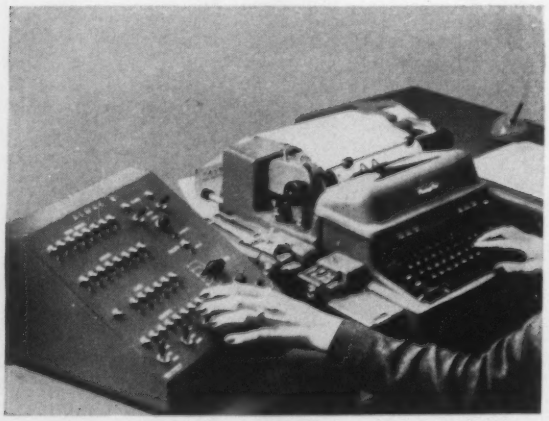
Other commonly used types of office machines are now available with tape-punching or tape-reading units. Each type will be mentioned only briefly here, with references in connection with specific applications of each made later.

Perhaps the simplest of the common language machines is a ten-key adding machine equipped with a unit capable of punching common language tape. This machine is, of course, limited in use to information of a numeric nature. It does not include tape-reading provisions, hence cannot be operated automatically by common language tapes, although the tapes it produces may be used in automatic operation of other common language machines.

INTEGRATED DATA EQUIPMENT



Tape punching device developed by the National Cash Register Co. operates in conjunction with a cash register. Data recorded on the cash register keyboard as source information are automatically punched into a five-channel tape by the recording device. This auxiliary equipment is experimental and no date has been set for production. Similar devices are being developed for use with bookkeeping and calculating machines.



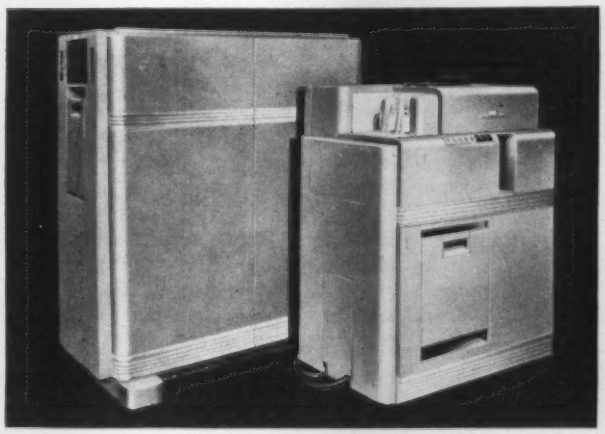
Electronic computer receives input information and instructions from five-channel tape and gives answers both in typewritten form and in perforated tape. The computer is Logistics Research Corp. ALWAC (*AUTOMATION*, August 1954) and the electric typewriter is a Flexowriter.

Embossed metal address-plate machines, on the other hand, are primarily readers of common language tapes produced by other machines. Preparation of embossed metal plates is by means of a punch-and-die set, usually controlled by a human operator. One model of plate-embossing machine, however, has been equipped with a tape-reading unit making the machine capable of accepting common language tape from other sources and embossing it into addressing machine plates automatically.

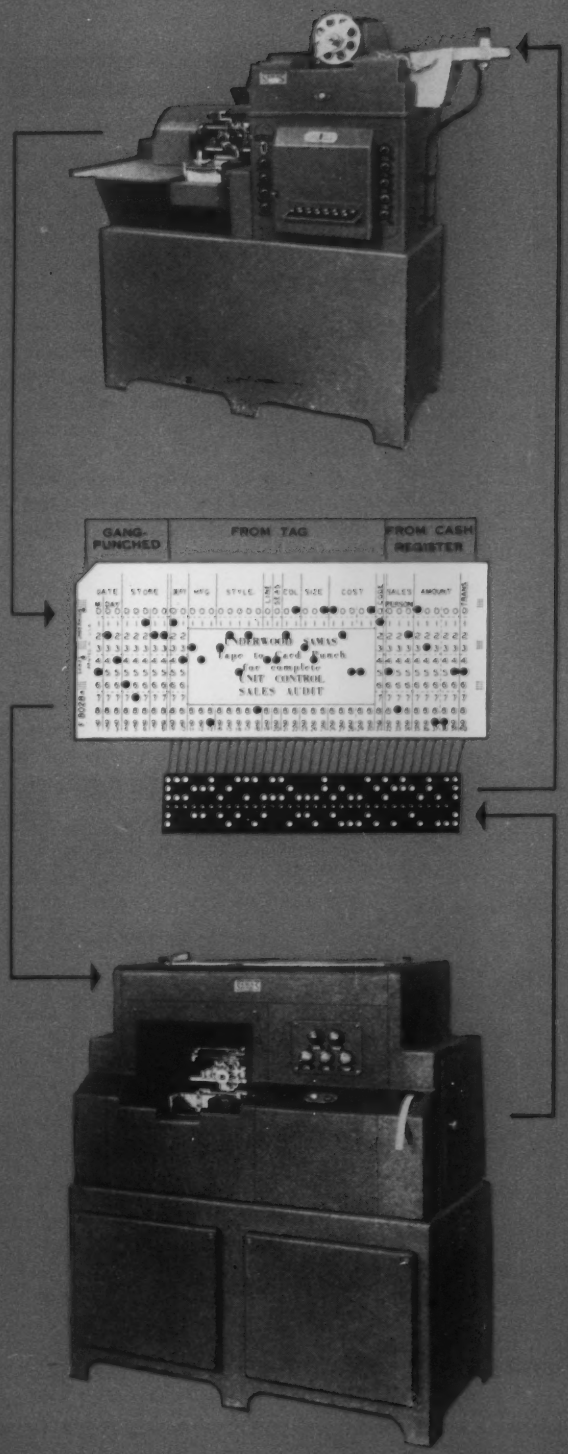
Another member of the common language family is the bookkeeping machine. Long capable of accepting key-inserted data, making desired calculations and printing the result—this machine is now able to punch the result into common language tape, simultaneously.

For use in those instances where information, normally recorded by cash register, is also needed in common language form, a cash register has been equipped with a tape punching unit. This machine produces a common language tape but does not incorporate provisions for reading from, or being operated automatically by such tapes.

For jobs requiring combined operations of typing and calculation, there is a unit in which a tape-punching and reading unit is linked to a large desk calculator. By the use of this device, a typist may operate both the typewriter and the calculator from a single keyboard. In this man-



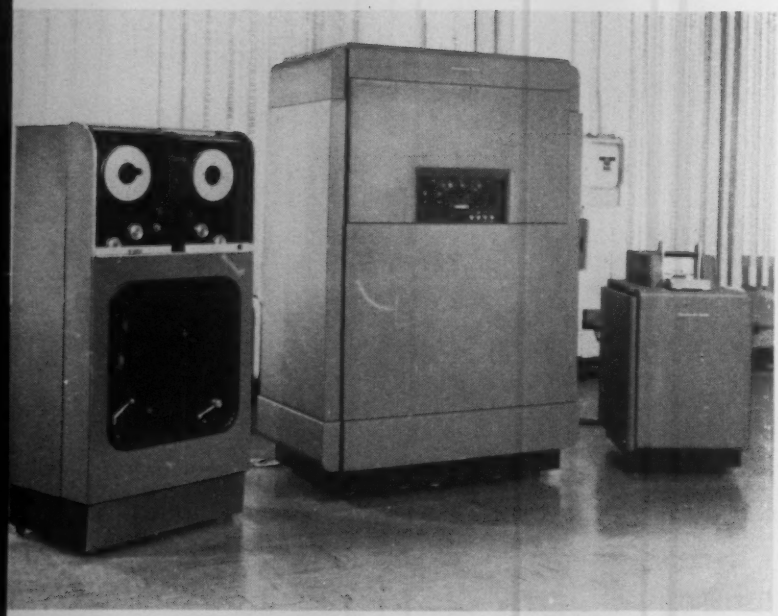
IBM punched card calculator, useful in an integrated data processing system through tape-to-card conversion. The unit record feature of punched card data, in addition to many variations possible with punched card equipment, complements perforated tape equipment. This calculator can go through as many as 60 separate steps to obtain the solution to a single problem. Answers are recorded in the same cards which carry the problem data or they can be punched in separate cards.



Tape-to-card and card-to-tape converters provide the integrated data processing system with advantages of both perforated tape data handling and punched card data handling. The Underwood Samas tape-to-card punch (top) makes possible punched card processing from the common language five-column tape. The card-to-tape punch (below) gives card systems the communication advantage of five-column tape and also provides a space saving medium by transfering records to perforated tape from punched cards.

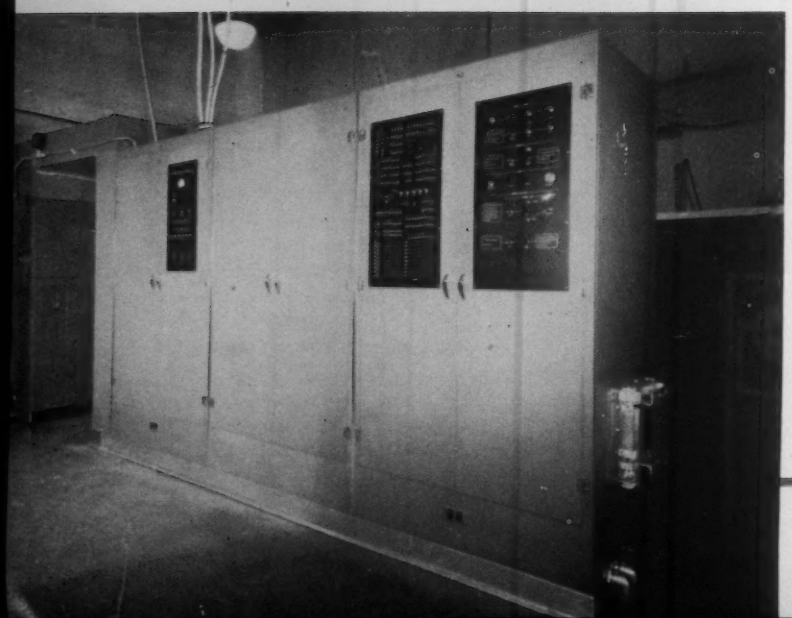
INTEGRATED DATA EQUIPMENT

Translating units are necessary to tie together machine languages other than the five-column tape. This IBM tape-to-card punch translates information in eight-column perforated tape form to standard IBM punched cards.



PUNCHED CARD TO MAGNETIC TAPE

Some computers use magnetic tape as the input-output media. In order to integrate these machines into a versatile data processing system, punched card to magnetic tape (top) and magnetic tape to punched card (bottom) converters are necessary. These converters make possible the use of Remington Rand UNIVAC in integrated data processing.



MAGNETIC TAPE TO PUNCHED CARD

ner progressive typing and intermingled calculation may be placed upon a document and simultaneously punched into a common language tape. The unit may also be operated automatically by common language tapes—either self-produced or from other sources.

Punched card accounting machines, being highly specialized devices, would require extensive redesign before they could operate directly from common language tapes. Indirectly, however, punched card equipment is made a usable part of the integrated data processing concept by existence of translating units. These devices can convert data from common language tape form into punched card form or from punched card form into punched tape form as required. This extra step of intermediate translation is performed rapidly and automatically. Its expense is more than offset by benefits gained through securing extremely desirable operating advantages offered by punched card processing of certain types of data.

▶ Basic Precepts

In general, these are the devices which now constitute the family of common language machines. This brief introduction to these machines, together with two basic rules for achieving integrated data processing, will provide the foundation for the more specific examples and applications to follow.

Keeping in mind the general characteristics of common language machines and the interchangability of information through use of common language tapes, here are the two simple rules:

1. Record data at the point of origin on office machines which create punched tapes or cards as the automatic by-product of the recording operation.
2. Process original and subsequent data on office machines which read and punch tapes or cards, so that all data are self-perpetuating.

Thoughtful analysis of these rules, relating them to the earlier example of stock-ordering, provides a hint of the powerful potential of integrated data processing to speed, simplify and reduce paperwork burdens by practical mechanization. If that stock clerk at the point of origin had recorded requisition data on a tape-punching typewriter—and had sent the tape with the purchase requisition to the purchasing department—then requests for quotation might have been prepared largely by automatic operation using another common language machine there.

Another by-product tape, resulting from typing requests for quotation, could have served to prepare the purchase order automatically—either by operating a common language typewriter to type the order, or by converting automatically into punched card form for punched card accounting machine use.

Thus in preparing each new document required to replenish the parts supply, all basic, repetitive data could have been self-perpetuating. In subsequent articles, these fundamentals will be expanded and examples given of their application to specific paperwork operations.

THE AUTHOR

P. B. GARROTT, director of the market development department, is a veteran of 19 years with Standard Register Co. Because of the company's unusual position as a designer of systems and supplier of business machine forms, Garrott has supervised the designing of most major integrated data processing installations in the country today. He has worked in close relationship with business machine companies and has had the opportunity to view the overall aspects of these systems rather than merely the various machine units involved.

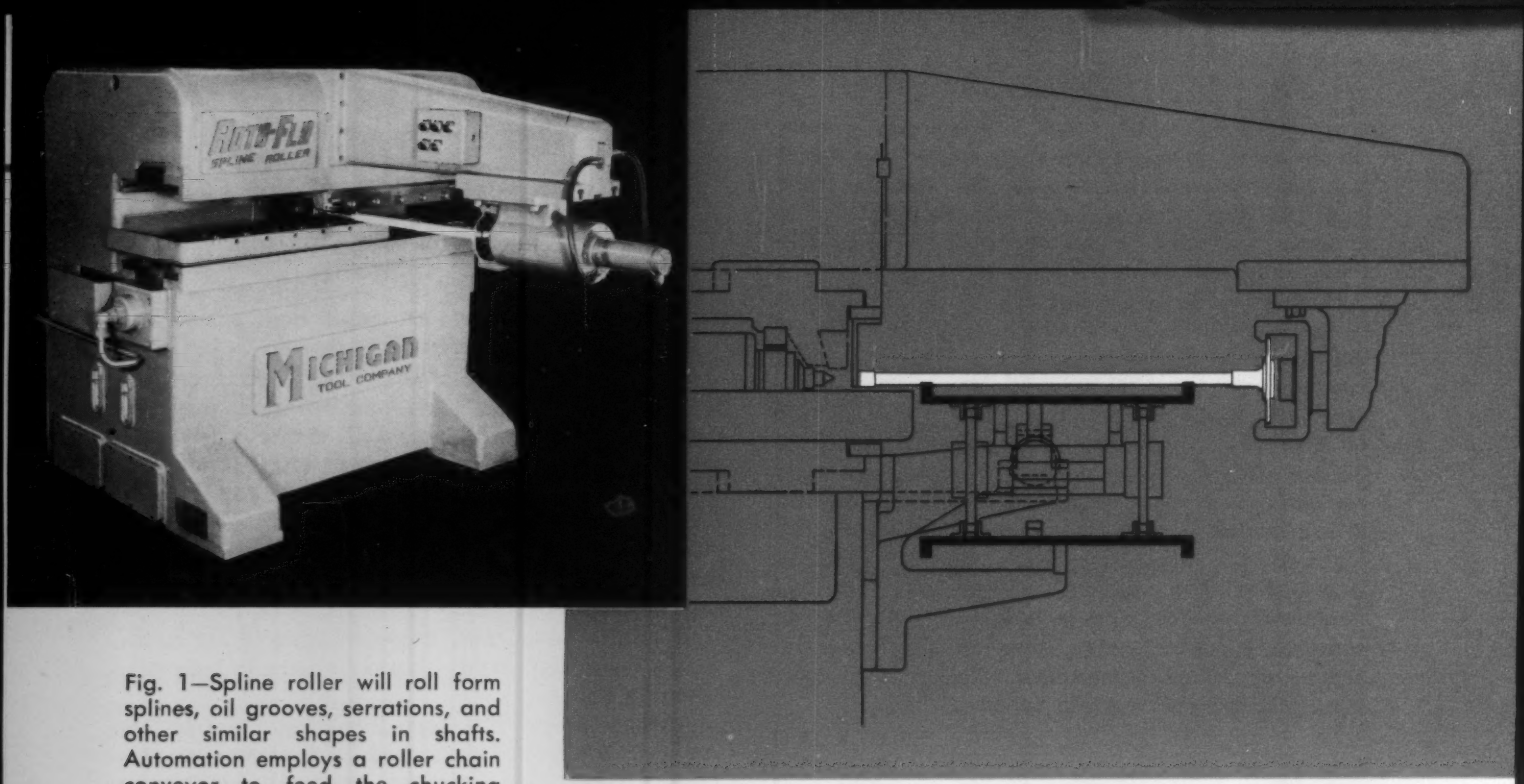
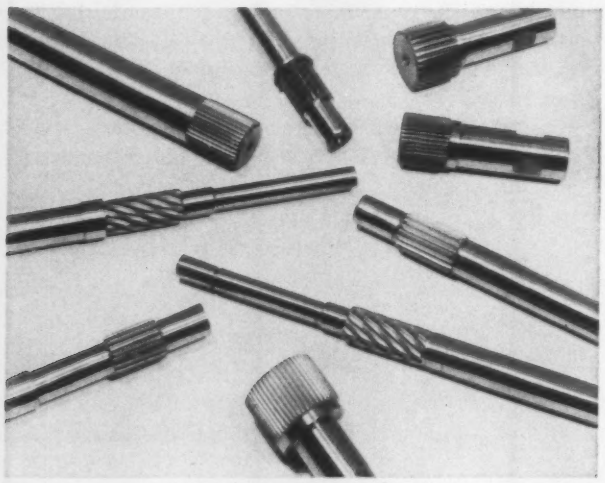


Fig. 1—Spline roller will roll form splines, oil grooves, serrations, and other similar shapes in shafts. Automation employs a roller chain conveyor to feed the chucking mechanism



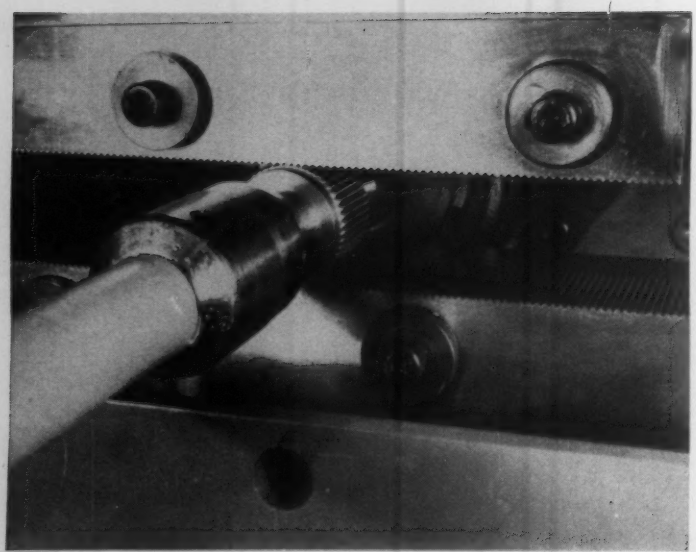


Fig. 2—Rolling an experimental axle shaft spline. Forming racks are specially ground from high-carbon, high-chrome steel. Tool life is extended because of the compressive forming loads rather than shearing action

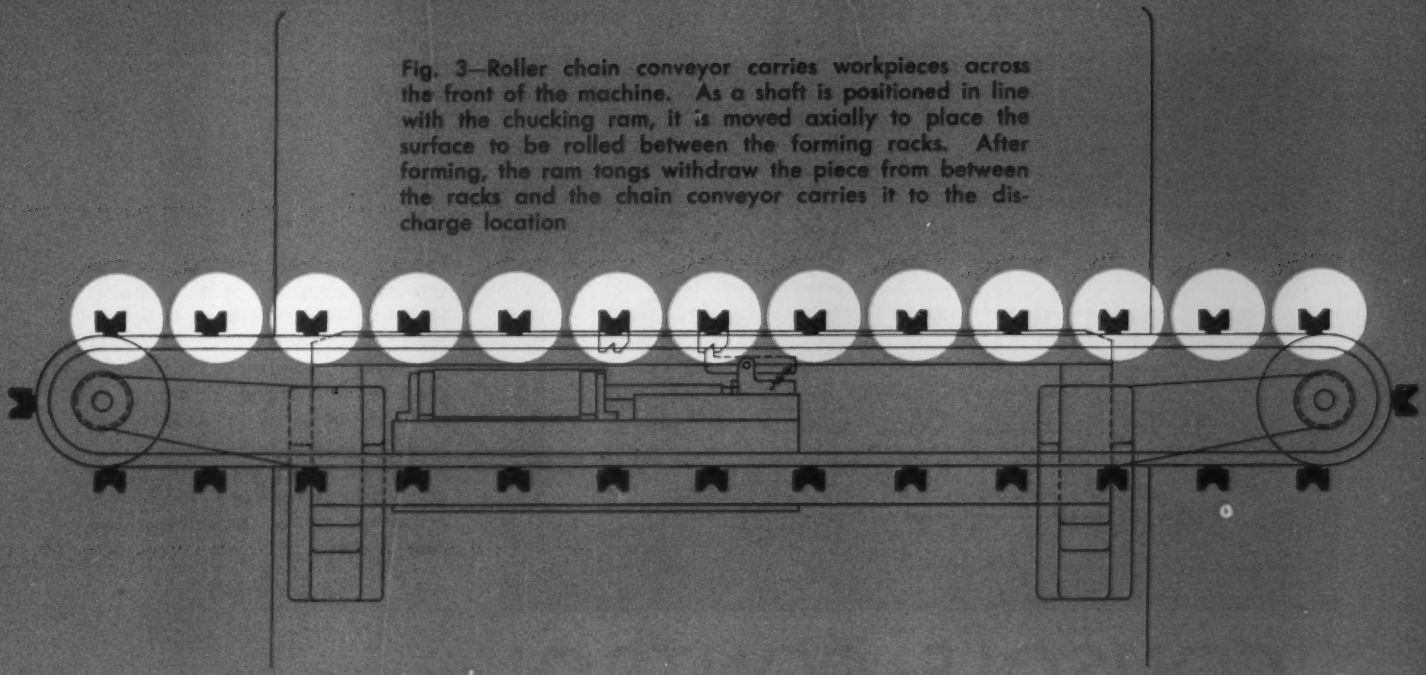


Fig. 3—Roller chain conveyor carries workpieces across the front of the machine. As a shaft is positioned in line with the chucking ram, it is moved axially to place the surface to be rolled between the forming racks. After forming, the ram tongs withdraw the piece from between the racks and the chain conveyor carries it to the discharge location

SPLINE ROLLING AUTOMATED

A NEW SPLINE ROLLING machine specially adapted for automation has been developed by Michigan Tool Co. Suitable for producing splines or similar shapes on heavy or awkward parts, the process offers real economy in production. Designed for rolling splines from a pitch size diameter, the machine uses two horizontal forming racks hydraulically actuated, *Fig.* 1.

Basic components of the Roto-Flo machine, beside the rack-type forming tools, are two slides and a heavy "C" shaped machine frame. The two slides holding the forming racks, *Fig.* 2 are mounted one above the other, geared together with master racks, (not the tool racks) and a connecting gear. The lower rack is the prime mover and gains its power from hydraulic cylinders. Tool racks are adjustable toward the part center to obtain proper size, and are also adjustable endwise to permit correct relationship with the part.

Parts to be formed are positioned between forming racks, supported between centers or by other suitable methods, so that the shaft is rotated by the movement of the racks. Racks are designed to press into the part until full depth is reached; then a few additional turns are made at full depth.

Roto-Flo machines are equipped with a safety interlock system that will not permit the forming racks to return until the workpiece has been removed. Also, the working stroke is delayed automatically until the part to be splined is properly located between the head and tailstock.

Special automatic loading and unloading devices have been designed to handle high-volume production from Roto-Flo spline rolling machines. A roller chain conveyor, *Fig.* 3, carries workpieces to the chucking device where each piece in turn is moved axially so as to position the diameter to be rolled between the forming racks.

Typical of production speeds obtained, splined shafts of $1\frac{1}{8}$-in. diameter and $1\frac{1}{4}$-in. length are formed in three seconds. Return stroke takes two seconds. Automatic handling of parts takes less than four seconds and the complete cycle for many parts is less than ten seconds.

In addition to the advantages of speed and automatic handling are the advantages of superior strength characteristics obtained from cold rolling and long tool life. Typical parts rolled from SAE 1037 steel in hardnesses ranging from annealed to 41 Rockwell C, show surface finish from three to six microinches and repetitive size accuracy over pins within 0.0008-inch.

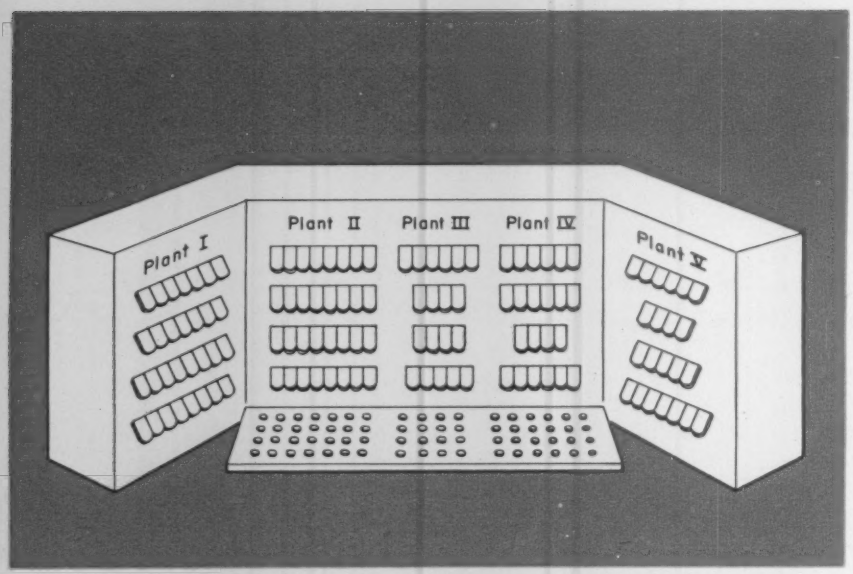


Fig. 1—Typical control console showing keys on vertical panel for individual switching and buttons on desk-size panel for multiple switch control. The system provides for rapid changing of multiple patterns in such industries as power generation where operation of a group of plants can be centralized—load dispatching, power balancing, turbines, etc.

CONSOLE CONTROL

PROVIDES FLEXIBLE AUTOMATIC OPERATION

USE of the name "console" for large control panels has been given a firm status by the recent developments of an organ manufacturer in master or central station controllers. Even discounting obvious similarities of appearance, the console of an organ and the industrial control panel have common functions of operation and can, therefore, be quite similar in mechanism design. Each has a series of keys or buttons to control individual movements and each has the requirement of master keys to actuate patterns—as shown in *Fig.* 1.

Designed and patented by E. R. Kilgen, president of Kilgen Aircraft Div., Kilgen Organ Co. the device substitutes control of some remote machine function for control of an organ pipe. This can be duplicated hundreds of times by using hundreds of keys—controlled switches. Then also, on the panel or console is a series of master pushbuttons. By depressing one of the pushbuttons and throwing the individual control switch to an "on" position, that switch is memorized to the pushbutton; or any series or quantity of switches may be memorized to that button, with the result that no matter in what position the switches may be set, as soon as that pushbutton is depressed, the same pattern comes back that has been memorized.

Its further advantage is that patterns may be "forgotten" or dropped instantaneously by depressing the pushbutton and throwing switches into "off" position; then a new pattern can be immediately set for the same button.

Pattern remembering plates, *Fig.* 2, are set by the individual control switches and entire patterns activated by master pushbuttons that move the plates. Linkages are all mechanical and actual switching at the ouput end of the linkages can be cam-operated limit switches.

One operating application for the console and its pattern setting feature is in control of high intensity lights at airports. The control tower has at its fingertips switches for individual lights or master switches for easily modified patterns of lights. Tailored for each application, the device offers centralized control with high flexibility for a multiplicity of automatically operated equipment or machines.

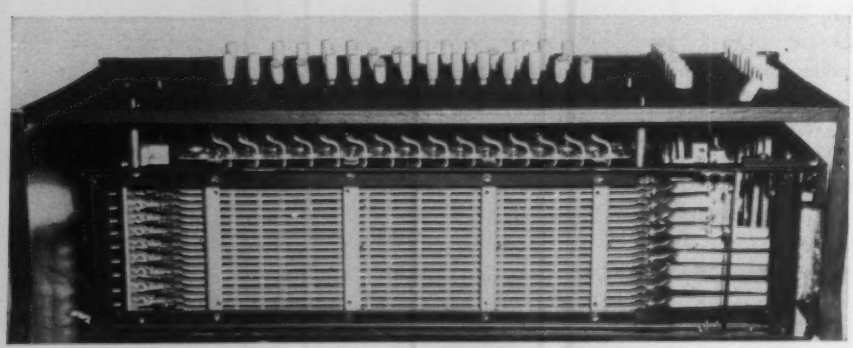
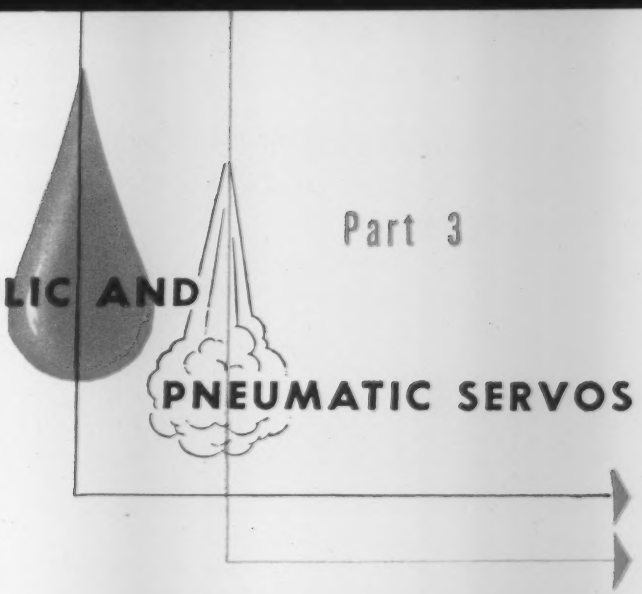


Fig. 2—View of control panel showing control and memory mechanism. Long plates contain the memory pattern as set by keys. Patterns are activated by pushbuttons on right



Part 3

HYDRAULIC AND PNEUMATIC SERVOS

BASIC SERVO ELEMENTS

Study pertaining to the basic characteristics of hydraulic and pneumatic power amplifiers leading to a discussion of the techniques for improving servo performance by means of passive networks or subsidiary loops

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Engineering Superintendent, Hydraulics

BASIC PRINCIPLES of servos have been discussed in the first two parts of this series of articles to develop the necessary background information. This and subsequent parts will be concerned with the specialized technology of hydraulic and pneumatic servo apparatus.

It has been explained how an error signal is obtained which must eventually take the form of a mechanical displacement or force in order to actuate hydraulic or pneumatic apparatus. The signal may, in the first place, be in the form of a voltage or other electrical quantity. In such cases, it may be convenient to "process it" by means of passive networks or other performance-improving apparatus before converting it to a mechanical quantity, but this is by no means always the practice.

It is, therefore, necessary to study the characteristics of basic hydraulic and pneumatic power devices or "amplifiers" which consist of motors of one form or another, controlled by a valve or variable delivery pump, in addition, study how the basic techniques for improving servo performance of fluid pressure apparatus by means of passive networks or subsidiary loops may be realized in practice. It is also desirable to review certain design aspects of some of the simpler components concerned, which have a direct influence on performance.

In certain elementary cases, it will be possible to study the performance limits of simple servomechanisms by analytical methods, and to derive immediately applicable criteria for satisfactory behavior. For more complex systems, resort must be made to the frequency response methods described in Part 2.

Basic Power Stages

Practically all fluid-operated servos depend on one of two basic principles: control of flow, or control of pressure, the controlled quantity then being fed to an appropriate motor. In the first case, the controlled flow is fed to a plain hydraulic cylinder,

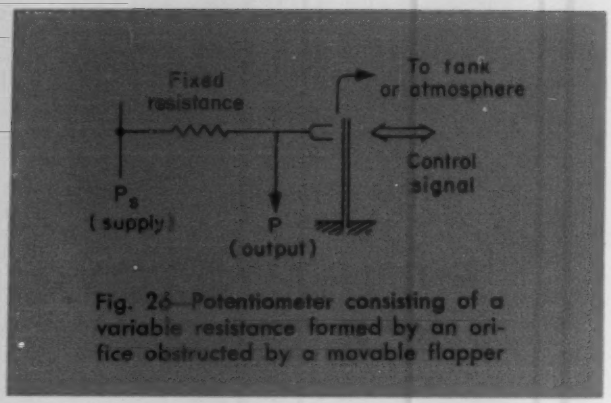

Fig. 26—Potentiometer consisting of a variable resistance formed by an orifice obstructed by a movable flapper

or what is practically its equivalent, a rotary hydraulic motor followed by reduction gearing. Motor displacement is then the time integral of the flow, and the combination of motor and amplifier (source of variable flow) then forms an integrating stage.

In the second case, i.e. control by pressure instead of flow, variable pressure is applied to a motor consisting of a spring-loaded piston or diaphragm, and will produce a movement of the latter proportional to the pressure change, provided the external load to be overcome by the motor is small as compared with the spring load. The resulting amplifier-motor combination then gives proportional action, as opposed to the integrating action obtained by flow control. In other words, the motor movement is proportional to the input signal applied to the amplifier, in the ideal case.

Control by pressure is practically universal on pneumatic as opposed to hydraulic servo-control of the *flow* of a gas is obviously difficult to obtain with any degree of accuracy, owing to compressibility. In pneumatic apparatus, the motor element is usually a spring-loaded diaphragm. Pressure control is also used fairly often in first-stage (consequently low power) amplifiers in hydraulic servos, the next stage then being flow controlled. The supply pressure is usually fixed, and there are several methods for obtaining a lower variable pressure from a fixed supply pressure. First method is to use a reducing valve. This solution is adopted in many power brakes which make use of pneumatic or hydraulic amplification, but are not closed loop systems. The chief method of importance for servo systems is to use some form of potentiometer. Perhaps the simplest type is that shown in *Fig.* 26, consisting of a variable resistance formed by an orifice obstructed by a movable flapper to which the input signal is applied, plus a fixed resistance which may also be an orifice, or a length of capillary tubing. Another good method for obtaining a variable pressure is to use an Askania type nozzle valve which will be described later.

In regard to flow control, flow must obviously be reversible as well as controllable in magnitude. Two basic solutions are possible: Provide a supply of oil at a more or less fixed pressure, and control flow by throttling, through use of a valve, as shown in *Fig.* 27. In this case, flow depends on the valve opening alone only as long as the load to be overcome by the motor is low in relation to supply pressure. The second solution is to apply the amplifier input signal directly, after preamplification if necessary, to a lever or other member controlling the output of a variable delivery pump, this output then being fed to the motor. This system is shown in *Fig.* 28. The variable delivery pump must of course be of the type in which delivery is reversed when the control lever is moved beyond zero or "neutral" point. With control by variable delivery pump, motor speed is only affected to a small extent by the load which it has to overcome, effect being due solely to leakage in the pump or motor. Flow control by a valve depends on throttling and implies some dissipation of power. Control by variable delivery pump involves power loss only to the extent that various components in the chain fall short of 100 per cent efficiency.

This feature of relatively high power conversion efficiency is probably the only justification for the use of control by variable delivery pump, which in all other respects seems to be inferior to valve control. Initially, pump control is somewhat more complex. This is particularly true when there are two or more associated servo loops such as an azimuth and elevation control for a gun; or aileron, elevator, and rudder control for an aeroplane. With pump control these would require one pump (a relatively complicated organ) for each loop, whereas with valve control a single pump will provide the power supply for any number of loops. Second, a variable delivery pump used as a control organ must be located in a place where it is accessible to the control linkage, which may be an inconvenience. For instance, in aircraft servos this consideration usually precludes the possibility of driving a control pump directly from an engine, and calls for a much heavier installation involving an electric motor. Third, systems with variable delivery pump control are subject to certain inaccuracies, in particular a "dead zone" effect near the neutral point (of which more will be said later),

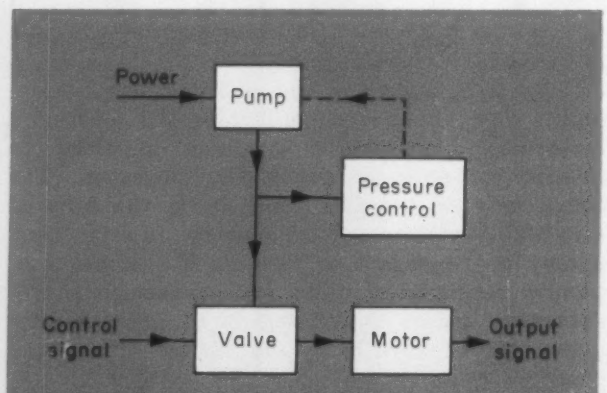

Fig. 27—Flow can be controlled through use of a basic valve amplifier system

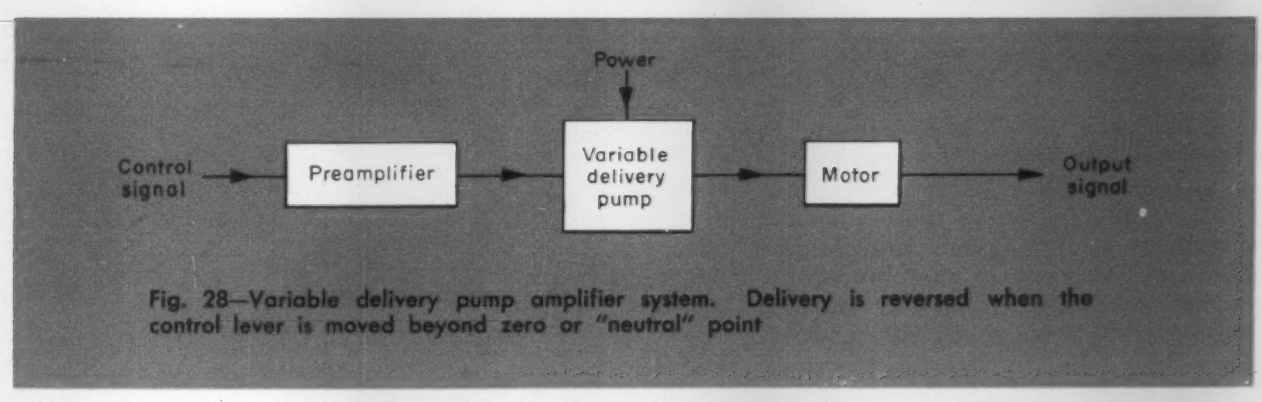

Fig. 28—Variable delivery pump amplifier system. Delivery is reversed when the control lever is moved beyond zero or "neutral" point

which may require additional complications for their elimination. Fourth, variable delivery pump control systems involve further complications, such as a practically inevitable preamplification stage (which is often avoidable with valve control) and "base pressurization", of which more will be said later. Power economy is by no means always a major or even an important consideration. In some cases, however excessive power dissipation, which implies heating of oil, may induce awkward cooling problems.

Before studying the above systems in more detail, it will be useful to consider certain questions pertaining to power supply, and working pressure, and various other preliminaries.

Power Supply

For pneumatic servos, compressed air mains are usually available. The pressure of these mains is usually too high and/or too variable for direct use, and some lower and accurately controlled pressure is then obtained by means of a reducing valve.

In valve-controlled hydraulic servos, the power source is almost invariably some displacement pump specially provided for the purpose, and it may be assumed that it is driven at constant speed. Under these conditions a *fixed* displacement pump is to be regarded as a source of approximately constant flow of oil, irrespective of pressure. Any flow surplus to instantaneous requirements must be disposed of, and in the simplest case this is done by fitting a relief valve, as shown in *Fig.* 29. The characteristics of interest for our purposes are those relating to flow downstream of the relief valve branch, i.e. the flow actually available to the control system. The ideal characteristics for such a system are shown by the line ABC in *Fig.* 30, and the real characteristics by the curve $AB'C'$. Slope of portion AB' is due to internal leakage in the pump. Drop from A to B' may be only 5 per cent for piston pumps fitted with seating valves. For rotary pumps—piston pumps with surface valves, gear pumps, vane pumps—and indeed all so-called "rotary" types, the drop may vary from 10 to 20 per cent, or even as much as 40 per cent for small high pressure pumps, at least when the oil gets hot. The slope of the portion $B'C'$ is due to the fact that in most relief valves blow-off pressure rises slightly with increasing flow. Flow plotted in *Fig.* 30 is the difference between pump delivery and flow through the relief valve. In practice, the slope of portion $B'C'$ may be made quite negligible, leading to a constant pressure supply. A definite slope may, however, be advantageous as it has some stabilizing effect.

For servo purposes no appreciable control is obtainable over portion AB' of the curve, *Fig.* 30, below the blow-off pressure of the relief valve. This is to be regarded as the "saturation region" of the characteristic, and the usual working region is the portion $B'C'$. It may be noted that the slope of the portion $B'C'$ may be artificially increased by inserting a resistance in the line, as shown in *Fig.* 31, if pressure is measured downstream of resistance. This device is also applicable to the other supply systems about to be described.

The circuit of *Fig.* 29 probably represents the simplest of all hydraulic supply systems, and perhaps the best (on this account) for powers up to 0.5 or 1 hp. The drawback is that the pump is always consuming peak power. For higher powers, the heating of oil becomes excessive unless forced cooling is provided, while unnecessary high power consumption may in itself be objectionable.

One method for reducing power dissipation is to use an accumulator and cut-out system, see *Fig.* 32. The cut-out valve responds to pressure at control connection C. When pressure at C

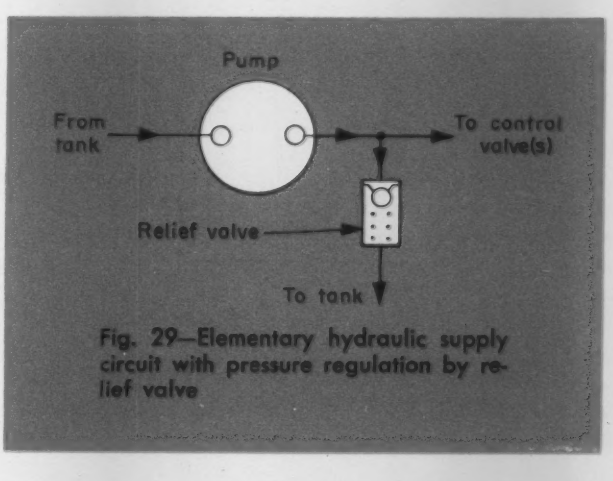

Fig. 29—Elementary hydraulic supply circuit with pressure regulation by relief valve

reaches the cut-out value connection A is opened to connection T, and the pump is unloaded by being short-circuited to tank, under which conditions its output pressure is little above atmospheric. When pressure at C drops to a value p_2 somewhat less than p_1 (usually by about 15 or 20 per cent), the short-circuit path is cut off. In servo installations, the accumulator is usually made of sufficient capacity to cope with peak power demands, and the capacity of the pump may then be reduced to a figure roughly corresponding to the average volume consumption rate of the servos which it supplies—a substantial margin being obviously necessary. Accumulators other than gas-loaded types are invariably ruled out on grounds of bulk at least, while gas-loaded accumulators require periodic reinflation. For these reasons, the cut-out system is by no means always the best solution.

The other main method of reducing power dissipation in valve-controlled servos is to use an "automatic" or "pressure-controlled" variable delivery pump which automatically adjusts itself according to the pressure in its delivery line. One simple method for obtaining automatic delivery control is shown in *Fig.* 33. Output pressure is applied to a small piston, opposed by a spring, acting on the delivery control lever. The resulting steady-state relationship between pressure and output is similar to that shown by curve $AB'C'$ of *Fig.* 30, but the saturation portion AB' may be made as short as desired, and portion $B'C'$ may be stretched out by a suitable choice of initial load and rate for the control spring. Under transient conditions, due to the fact that the delivery control piston takes finite time to fill, there will be a time lag between output and pressure, which may be represented (at least approximately) by a factor $1/(1 + t_1 s_Q)$ in the transfer junction between the two quantities, where t_1 can be easily calculated

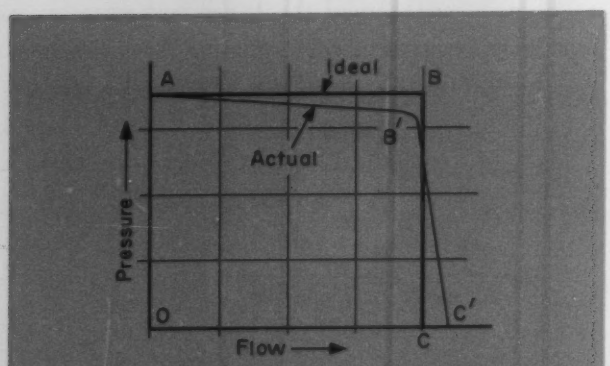

Fig. 30—Flow pressure characteristics of hydraulic supply source. Flow shown is the difference between pump delivery and flow through the relief valve

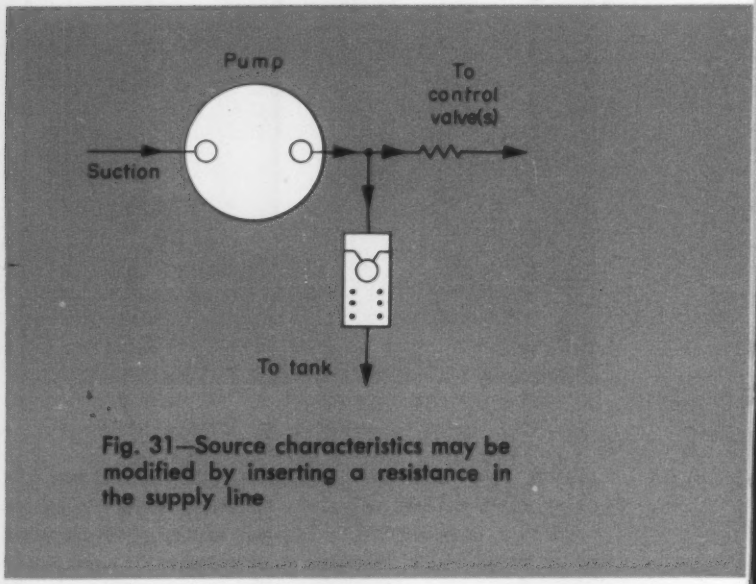

Fig. 31—Source characteristics may be modified by inserting a resistance in the supply line

from first principles. If the portion $B'C'$ is made very steep the characteristic is again one of nearly constant pressure, and any time lag is practically irrelevant in regard to the overall characteristics of the servo. It is, however, relevant for preventing pressure surges which may be substantial if the pump delivery control has a high time constant, in which case a relief valve may be necessary. In practice small surges are absorbed by the elasticity of the oil in the system. Various other more elaborate, and sometimes superior, methods of delivery control are also in use,[9] which we shall not describe here. Some of these methods allow the characteristic shape of portion $B'C'$, *Fig.* 30, to be adjusted at will.

Variable delivery pumps are not a universal solution to the power economy problem as they are considerably more complex than constant delivery types, and perhaps less reliable—especially when used with pressure control—when they spend much of their working life under particularly unfavorable combinations of maximum pressure and near-zero output.

The use of automatic variable delivery pumps as supply sources should not be confused with the use of variable delivery pumps as amplifiers, i.e. as direct means of flow control. In the latter case, the pump is actuated directly by the error signal—or some other signal later in the loop—and must be reversible, but carries no pressure-governing device. Otherwise, similar basic pump types are usable in both applications.

▶ Working Pressures

Most pneumatic servos depend on some available compressed air supply, the pressure of which is usually below 100 psi. Typical working pressures for pneumatic process controllers are in the order of 15 psi. Such low pressures are sufficient for powers required in the majority of process con-

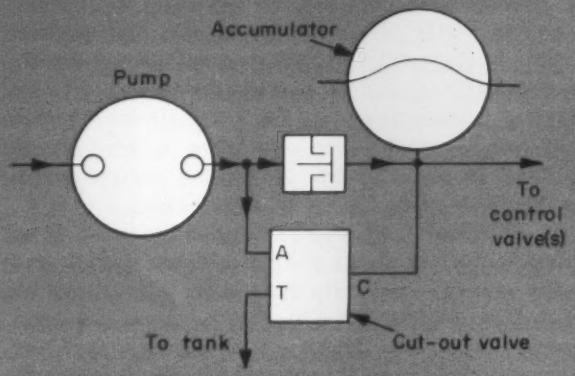

Fig. 32—Supply system utilizing an accumulator and cut-out system such that pump is not constantly consuming peak power

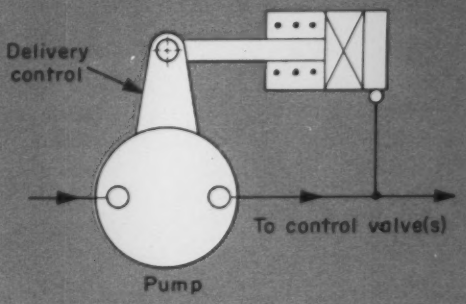

Fig. 33—Supply system with automatic variable delivery pump. Output pressure is applied to a small piston, opposed by a spring, acting on the delivery control lever

trol problems, and facilitate detail design of apparatus.

In hydraulic servos, the pressure can usually be chosen at will. High pressures are favorable in that they reduce sizes of pipes, valves, and cylinders, and often allow higher gain per stage. One factor of importance in the choice of working pressure is its effect on the elasticity of the system, as elasticity usually has a destabilizing effect in servomechanisms (this will be investigated in more detail later). Incidentally, the bulk modulus of elasticity of oil is about 250,000 psi. Inclusions of suspended air in the oil seem to be inevitable, and these have a drastic lowering effect on the bulk modulus. The higher the pressure the less this effect, and hence excessively low working pressures are unfavorable, at least for high power servomechanisms with high inertia loads. Perhaps 500 psi is a lower limit for such cases. On the other hand, beyond the point at which any suspended air is compressed to negligible proportions, any further increase in pressure raises the effective elasticity (i.e. makes the system softer), and is disadvantageous from this standpoint. To prove this, consider a motor in the form of a cylinder subject to a load F, and let p be the pressure corresponding to that load. The cylinder must then have a cross section area $A = F/p$. If L is the stroke and K the bulk modulus of the oil, the volumetric compression is pAL/K, and the linear deflection is $pAL/KA = pL/K$, i.e. directly proportional to the pressure p. If the motor is of rotary type (followed by reduction gearing), volume of oil in the motor itself is usually negligible, and the effect of compressibility is less important. Main factor in this case is the volume of oil in the pipes, and as far as this is concerned pressure effect is more complicated, since the cross-section area of the pipes will not necessarily vary exactly in inverse proportion to pressure—effect is still adverse in most cases.

Another unfavorable effect of high pressure is that, for a given power, valve dimensions and travels decrease with increasing pressures, and the required precision in workmanship increases accordingly. This may be quite an important factor in valves for high performance servomechanisms, which require workmanship of a very high order.

Where none of the above factors is decisive, the question may be settled on economic grounds. Thus inexpensive gear or vane pumps are available for pressures up to about 500 psi; somewhat more refined and expensive types of rotary pumps are made for pressures up to 1500 or 2000 psi; while for still higher pressures, piston pumps are the rule, and these are more expensive still.

Hydraulic process controllers, in which the power is often less than 100 watts, often work at pressures in the order of 100 psi. Copying machine tools and other commercial servos of relatively low power may work at pressures of 300 to 500 psi. High power servos such as gun controls may work at 1500 psi or higher, while for aircraft applications, in which low weight and size are paramount considerations, pressures of 3000 psi may be used. In general, the higher the power the more advantageous it is to use high pressures, except as regards elasticity effects.

▶ Motors

Hydraulic motors of continuous rotary type are essentially pumps working in reverse, and may be gear, vane, piston or various other types. Pumps, in which distribution ("commutation") depends on non-return valves, will not work as motors, but in any event specialized designs are the rule since most pumps will not work efficiently in reverse. Just like plain cylinders, motors of this type will reverse their direction of motion if their two connections, "pressure" and "outlet", are interchanged.

In servos, motors of the cylinder type are usually double-ended as in *Fig.* 1 (Oct.—AUTOMATION),

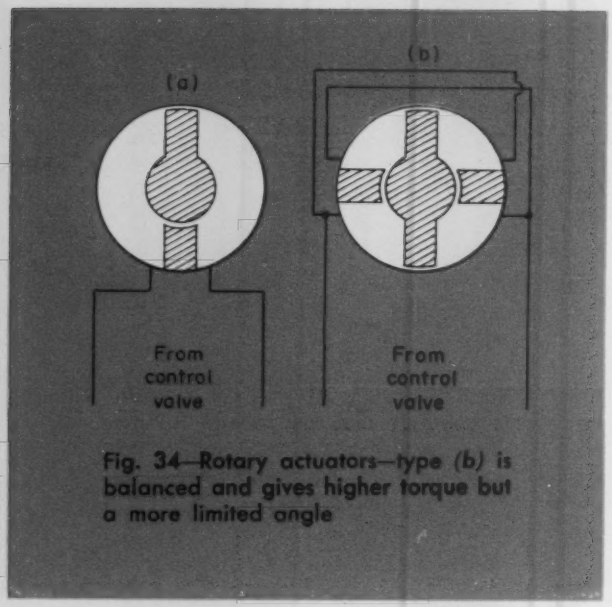

Fig. 34—Rotary actuators—type *(b)* is balanced and gives higher torque but a more limited angle

to equalize characteristics in both senses although this is not always necessary. Rotary motors of the non-continuous type, giving high torques over a range of movement less than one complete revolution, are also feasible, examples shown in *Fig.* 34. Like cylinders, these also avoid reduction gearing.

In most pneumatic servos, the motor is in the form of a spring-loaded diaphragm. This will be illustrated, and its characteristics analyzed, in a later section.

Basic Types of Servo Valves

The two most important types of servo valve are seating valves and cylindrical slide valves. Rotary valves are basically similar to slide valves, and need no separate discussion. From the standpoint of their use in servos, most control valves should be regarded as variable resistances, or sets of resistances.

Seating valves require substantial operating loads unless the pressure and size are both quite low. Pressure balance can be achieved in theory, but is not easily obtained accurately, and seldom attempted. Consequently, seating valves are usually restricted (as far as servos are concerned) to quite low power applications, in particular pneumatic process controllers, and also as first stage amplifiers in some hydraulic servos; second stage then being a slide valve in most cases.

The simplest and most commonly used type seating valve for servo purposes is an orifice and flapper arrangement, which is most often used in conjunction with a fixed orifice to form a potentiometer, as in *Fig.* 26. A useful arrangement for a preamplifier stage is a flapper between two opposing orifices, in conjunction with two fixed resistances, forming a Wheatstone bridge, as shown in *Fig.* 35—flapper balanced in the central position. In all these and similar devices, outlet from the orifices is to atmosphere in the pneumatic instance, or to a space connected to tank in the hydraulic system.

Two other useful types of seating valve, which are in effect potentiometers with both resistances variable, are shown in *Fig.* 36. If both seats are of the same size the operating load is constant for a constant supply pressure P_s. By making the seats of different sizes as shown in the figure, the load can be made to increase with increasing output pressure P, which is sometimes a useful characteristic, as will be shown later.

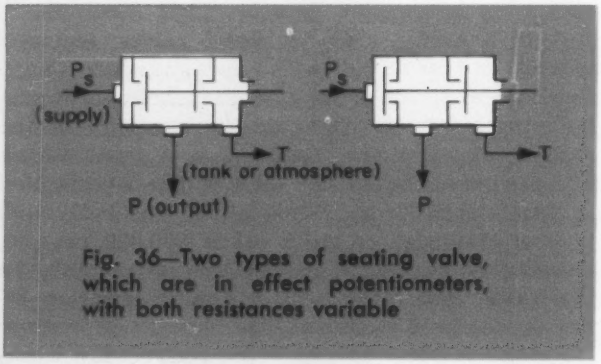

Fig. 36—Two types of seating valve, which are in effect potentiometers, with both resistances variable

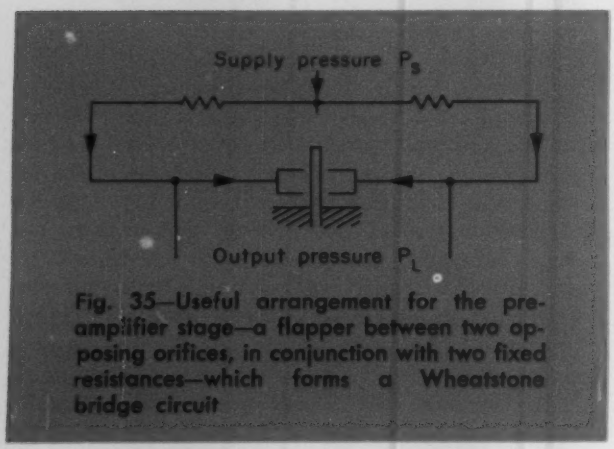

Fig. 35—Useful arrangement for the preamplifier stage—a flapper between two opposing orifices, in conjunction with two fixed resistances—which forms a Wheatstone bridge circuit

Most important basic type slide valve is the four-way kind shown in *Fig.* 37. This is shown in three forms: "ideal" valve with zero lap; positive lap or "overlap"; and negative lap or "underlap"—the meaning of these terms being clear from the diagram. The laps need not necessarily be equal on the two sides of each groove, but are usually made so. The order of lap magnitude in servo valves may be 0.002-in., or often lower. With positive lap there is a dead zone equal to the amount of lap. Hence, such valves are unsuitable for accurate servos, unless the dead zone effect is counteracted by "dither", i.e. a steady high frequency oscillation superimposed upon the actuating signal, and having an amplitude somewhat higher than the amount of lap. Dither is beneficial for other purposes, and will be referred to later.

The ideal valve is useful as an object to theorize about, but can only be approximated in practice, because of manufacturing tolerances which are quite high in relation to significant amounts of lap. In high accuracy servos where dither is not used, it is desirable to provide at least a slight nominal underlap in order to avoid overlap when tolerances are adverse.

For displacements less than the amount of lap, an underlapped valve is in effect a Wheatstone bridge, the four arms of which are denoted by R_1, R_2, R_3, R_4, in *Fig.* 37.

Another commonly used slide valve is the three-way type shown in *Fig.* 38, which again shows "ideal", overlapped and underlapped types. The underlapped valve is in effect a potentiometer, within the range of underlap, beyond which the resistance of one of the arms is infinite.

A very effective servo type valve is the Askania nozzle, shown in *Fig.* 39. The space outside the nozzle is at atmospheric pressure, and the pressure energy of the fluid is entirely converted to kinetic energy in the jet at the nozzle exit. This is reconverted to pressure in the tapering passages of the receiving block, the reconversion pressure being determined entirely by the load, i.e. resistance offered to the output flow. Valve principle allows the nozzle to operate a good distance from the receiving block, and leads to the following advantages: insensitivity to dirt and low friction loads. As shown in *Fig.* 39, the oil supply may be through a close-fitting rotary joint, although close fitting surfaces subject to pressure gradients usually generate friction forces. According to S. Z. Dushkes and S. L. Cahn[11], however, the slight vibration which is always present in the nozzle valves reduces this friction considerably. Construction of *Fig.* 40, in which the fluid supply is through a second (fixed) nozzle, reduces friction still further. Another advantage is that hydrodynamic loads, which are quite appreciable with slide valves, are negligible in nozzle valves.

A valve tested by the author required an operating load of about 3 grams, and a travel of ± 0.02 in. for a flow capacity of 4 cubic inches per second at 100 psi. Characteristics of nozzle valves have been studied in some detail by Dushkes and Cahn[11]. A maximum pressure reconversion practically indistinguishable from 100 per cent is obtainable. The shape of characteristic curves is shown in *Fig.* 41, for conditions of output blocked, and output short-circuited, the latter condition corresponding near enough to the output being connected to a cylinder subject to very small load. It is seen that very good linearity is maintained to quite high travels. The author understands that the best proportions for receiving block orifices are a diameter equal to $\sqrt{2}$ times that of the nozzle tip.

Askania nozzles have found most of their application in hydraulic process controllers, but have also been used as first stage devices in high power

[11] See reference at end of article

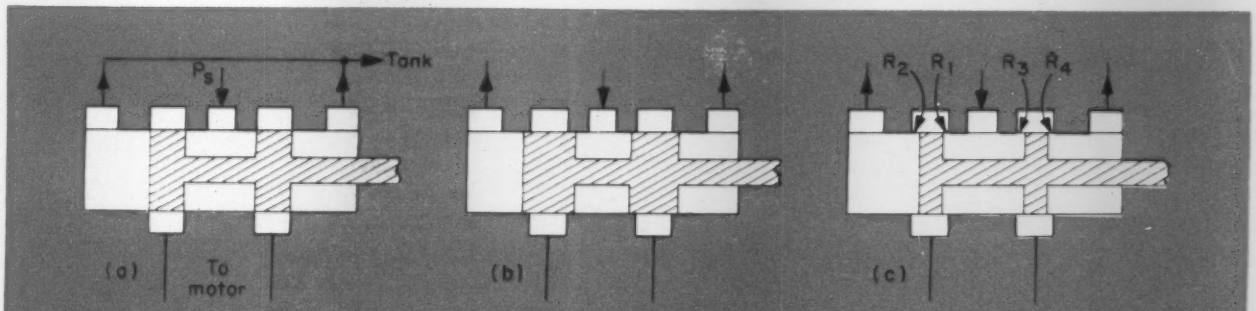

Fig. 37—Four-way slide valve shown in three forms: *(a)* "ideal" valve with zero lap, *(b)* positive lap or "overlap", and *(c)* negative lap or "underlap"

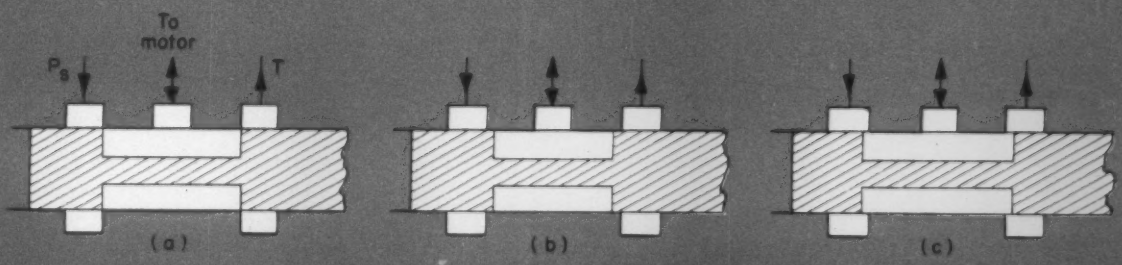

Fig. 38—Three-way slide valve which shows *(a)* "ideal", *(b)* overlapped and *(c)* underlapped types

hydraulic servomechanisms. They will work with air as well as oil.

There are two basic methods for using nozzle valves; first is to connect them to a cylinder or other motor like an ordinary four-way valve; second is to block one of the receiving orifices, and connect the other to a spring-loaded diaphragm or equivalent element. This method makes use of the "blocked output" characteristic of *Fig.* 41, and the nozzle valve is then equivalent in its action to a potentiometer arrangement.

Fig. 42 shows a type of valve used in some pneumatic process controllers as an alternative to the orifice and flapper arrangement, due to its lower operating load. It is in effect a form of slide valve.

Automatic valves such as relief valves, reducing valves, etc. used in servos need be no different from those employed in ordinary hydraulic or pneumatic installations, and require no special description. Since this is a text on servos it is worth noting that such valves are in fact self-contained closed loop systems; indeed some of them are systems embodying subsidiary loops. Like other closed loop systems, automatic valves are subject to instability and servo theory could no doubt be used to advantage in dealing with this.

Principles of Pressure Control

As already mentioned, pressure control is obtained by using a potentiometer arrangement, or a nozzle valve, and connecting the controlled pressure point to a spring-loaded piston or diaphragm. A system with potentiometer is shown in *Fig.* 43. Either the resistance R_1 only is variable, as in *Fig.* 26; or both arms may be varied at once, using valves of the type shown in *Fig.* 36 or *Fig.* 38 with high underlap. In order to analyze this system, it will be assumed that resistances are linear, i.e. that pressure drop is proportional to flow.

Let y be the diaphragm travel, F the external load to be overcome by the motor, g the spring rate, and A the effective area of the motor, other quantities being as shown in the figure. Then $P = P_s - R_2 (q_1 + q_2) = R_1 q_1$, q_1 and q_2 being the flows in the branches indicated. If "s" stands for d/dt, we also have $Asy = q_2$. If y is measured from the point at which spring load is zero, $PA =$

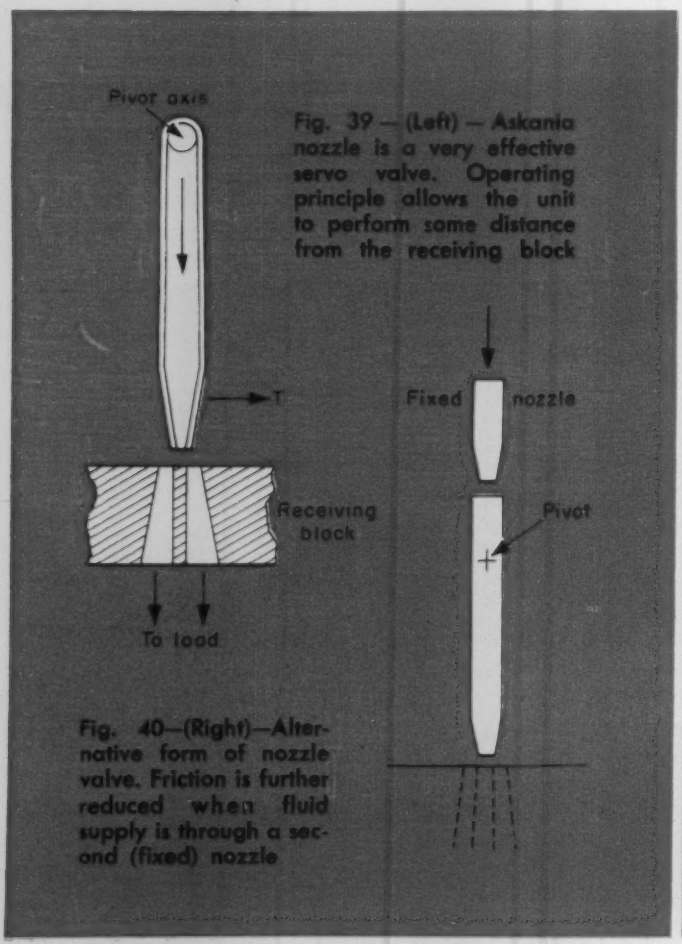

Fig. 39 — (Left) — Askania nozzle is a very effective servo valve. Operating principle allows the unit to perform some distance from the receiving block

Fig. 40—(Right)—Alternative form of nozzle valve. Friction is further reduced when fluid supply is through a second (fixed) nozzle

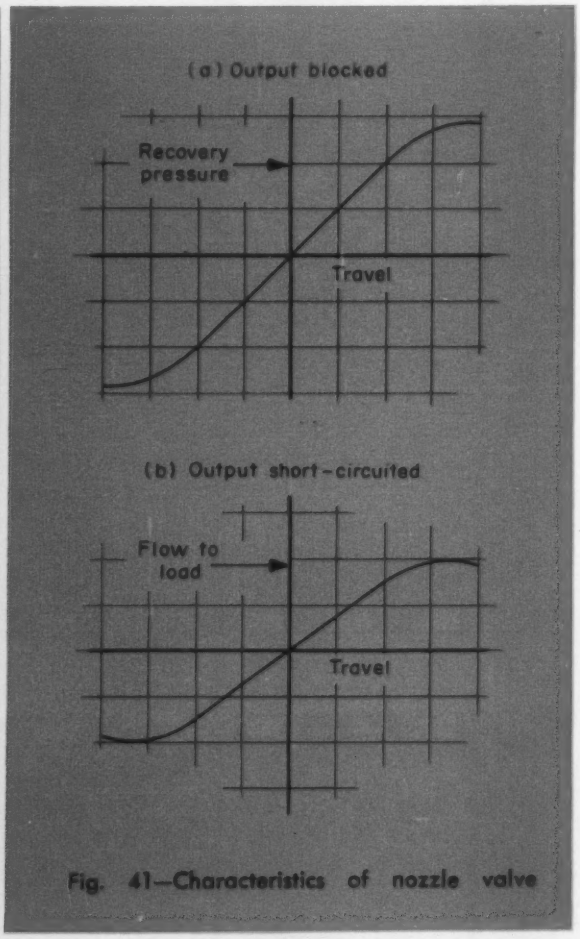

Fig. 41—Characteristics of nozzle valve

$gy + F$. Combining these equations, we get

$$y\left(1 + \frac{A^2}{g}\,\frac{R_1 R_2}{(R_1 + R_2)}s\right) = P_s\,\frac{A}{g}\,\frac{R_1}{(R_1 + R_2)} - \frac{F}{g}$$

This expression does not give a true transfer function because the coefficient of s is not in general constant. If R_1 and R_2 both vary, one will increase while the other decreases and $R_1 R_2/(R_1 + R_2)$ may remain almost constant; at least it can be regarded as constant over relatively small variations, and as a true constant for purposes of calculating the response to a displacement step function. Allowing for approximation when necessary, we may write the time constant of the valve-motor combination as

$$t_1 = \frac{A^2}{g}\,\frac{R_1 R_2}{(R_1 + R_2)}$$

we may regard $R_1/(R_1 + R_2)$ as the input signal, which we shall denote by x; then if the external load F is zero, the transfer function becomes $y/x = K/(1 + t_1 s)$ where the gain factor $K = P_s A/g$. This expression will still apply, with a suitable redefinition of "x", if any other datum point is taken for "y". The response to a displacement step input x_o is

$$y = Kx_o\,(1 - E^{-t/t_1})$$

which is shown in *Fig.* 44.

It would appear at first sight that any substantial external load would introduce such errors that this type of control would become useless. However, this is not so, if the apparatus under discussion is part of a closed loop. Consider the simplest possible example, where the loop is immediately closed by a mechanical linkage around the valve and motor, as shown by the dotted lines in *Fig.* 43. Under steady-state conditions, term in "s" is zero, and the equation may be written $y = Kx - F/g$

In this case, however, x is the error $= \theta_i - y$, where θ_i is the input. This gives

$$y = \frac{K}{1 + K}\,\theta_i - \frac{F}{g(1 + K)}$$

or, if K is large as it always will be, $y \simeq \theta_i - F/gK$.

Thus the steady-state error due to the external load is F/gK, which will be quite small if K is large.

With the loop closed in the manner just described, and if external load is negligible, the overall transfer function becomes

$$\frac{y}{\theta_i} = \frac{K}{(K + 1)\left[1 + \dfrac{t_1 s}{K + 1}\right]}$$

The diaphragm must be proportioned to the magnitude of the load, according to the application. If the load is high the time constant t_1 may become excessive, leading to a sluggish response.

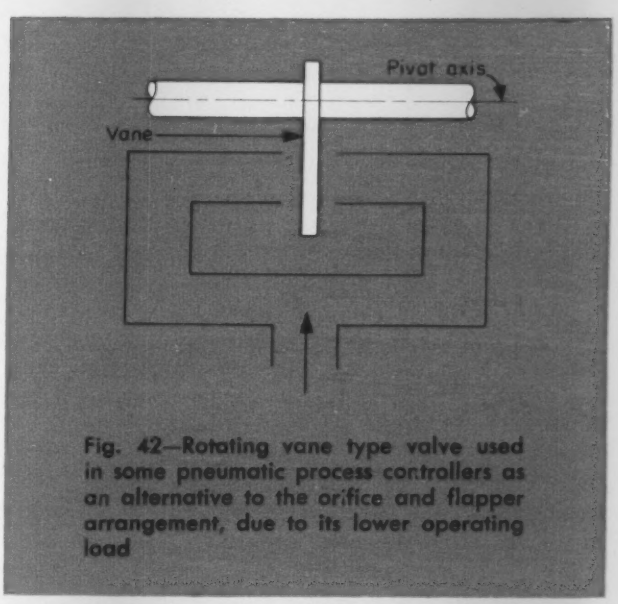

Fig. 42—Rotating vane type valve used in some pneumatic process controllers as an alternative to the orifice and flapper arrangement, due to its lower operating load

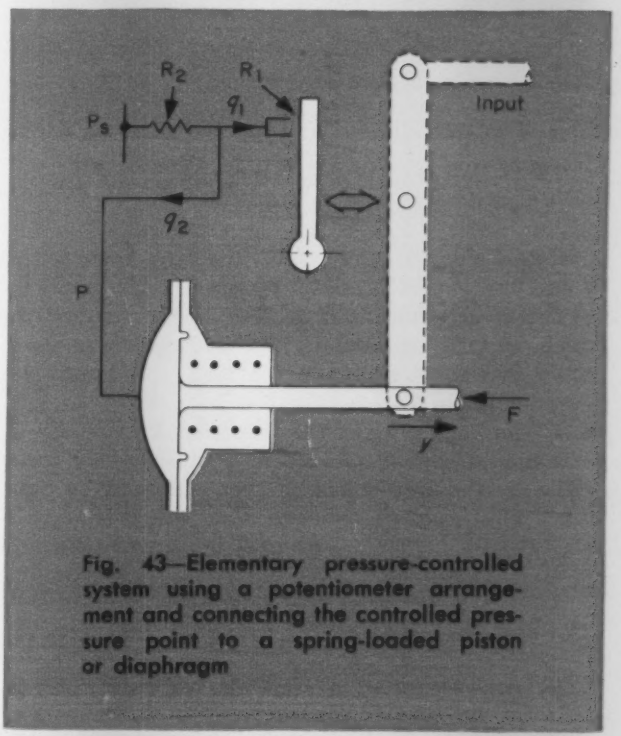

Fig. 43—Elementary pressure-controlled system using a potentiometer arrangement and connecting the controlled pressure point to a spring-loaded piston or diaphragm

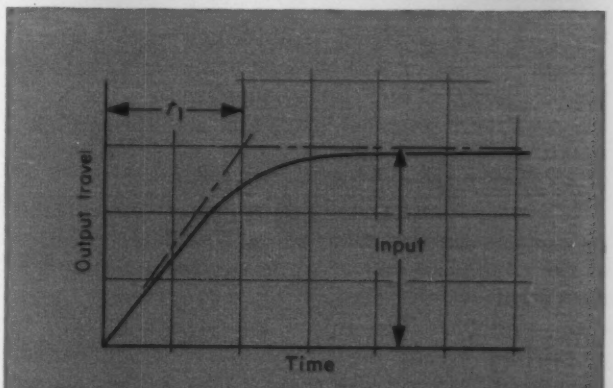

Fig. 44—Response of system shown in *Fig.* 43 to step function input

In process control equipment when this difficulty arises it is often overcome by using quite a small diaphragm connected to the potentiometer or other signal source, and driving another valve through a purely local servo loop closed by a mechanical linkage. This valve, in turn, actuates a larger diaphragm or cylinder big enough to deal with the load. The second valve may be made large enough, or in other words with sufficient "gain", to avoid introducing any appreciable further time lag. This type of apparatus is known as "valve positioner". Its function is usually to control a valve in some chemical process. The use of a valve positioner practically eliminates direct errors due to load, and helps to keep time constants low.

Where the diaphragm moves the load directly, consider again the basic equation

$$y\,(1 + t_1 s) = \frac{1}{g}\left(P_s A \frac{R_1}{R_1 + R_2} - F\right)$$

With a step function input, the first term within the bracket on the right-hand side is equal to the full steady-state load exerted by the diaphragm, which will be denoted by F_o, and which is used partly in compressing the springs and partly in overcoming the external load F. As shown in *Fig.* 44, at the beginning of the response the velocity is a maximum, and displacement y is obviously zero.

The maximum velocity is then obtained by putting y (but not sy) equal to zero, which is

$$v = sy = \frac{1}{gt_1}(F_o - F)$$

The power exerted against the external load is given by Fv, and is proportional to $F(F_o - F)$, which is a maximum when $F = F_o/2$. This may be taken as a criterion of optimum operating conditions; the latter will then be achieved by making the diaphragm just large enough to give twice the maximum external load, and the springs such that their force will be equal to the external load at or near their maximum deflection.

In most potentiometer arrangements the variable resistance (or resistances) is a definite function of the applied signal, which is usually a mechanical movement of the flapper or valve stem. Under such conditions the output pressure will vary in proportion to the supply pressure, which cannot always be regarded as constant to a high degree of accuracy. Thus any change in supply pressure will cause "drift", i.e. change in the motor position corresponding to a zero input signal. There will also be a corresponding change in gain factor, which is unimportant. Just like errors due to external loads, drift is minimized by closure of the loop, but in some cases, and particularly with complicated loops, it may be desirable to eliminate drift at the source. One method of doing this is to introduce a bias piston directly connected to supply, and replace the motor bias spring by a spring centering arrangement, which exerts zero load in the "neutral" position of the motor (corresponding to a zero applied signal at the potentiometer). This arrangement, using pistons instead of diaphragms, is illustrated in *Fig.* 45.

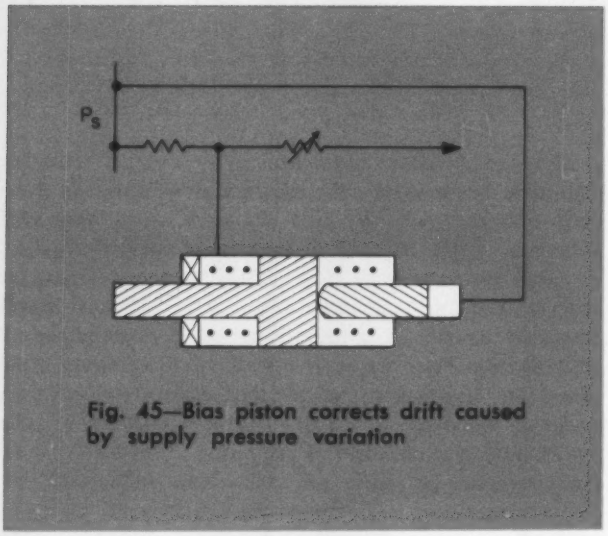

Fig. 45—Bias piston corrects drift caused by supply pressure variation

Another method of eliminating drift is feasible if the applied signal is supplied by an electromechanical transducer such as a moving coil movement. As noted in the discussion of these devices in Part 2, they are basically sources of force which may be converted to displacement by adding springs of suitable rate. Now seating valves of the orifice and flapper type (and several other servo valves of the seating type) require an operating force proportional to the output pressure. Hence in the absence of springs on the transducer, such valves will produce an output pressure determined solely by the transducer current, irrespective of the magnitude of supply pressure. A bias spring of sufficiently low rate would not upset this characteristic, but merely produce a fixed shift in the datum point. Using a transducer as a movement-producing instead of a force-producing device would appear to have a disadvantage. In order to get an accurate *movement* signal, the load exerted by the control springs must be high in relation to any external load hence the transducer is being used inefficiently, its force being wasted in compressing springs which do no useful work.

Fourth part of this series, to cover flow control with valves, will appear in the January issue.

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11. S. Z. Dushkes and S. L. Cahn—"Analysis of some Hydraulic Components used in Regulators and Servomechanisms." *Transactions of American Society of Mechanical Engineers*, New York, 1952.

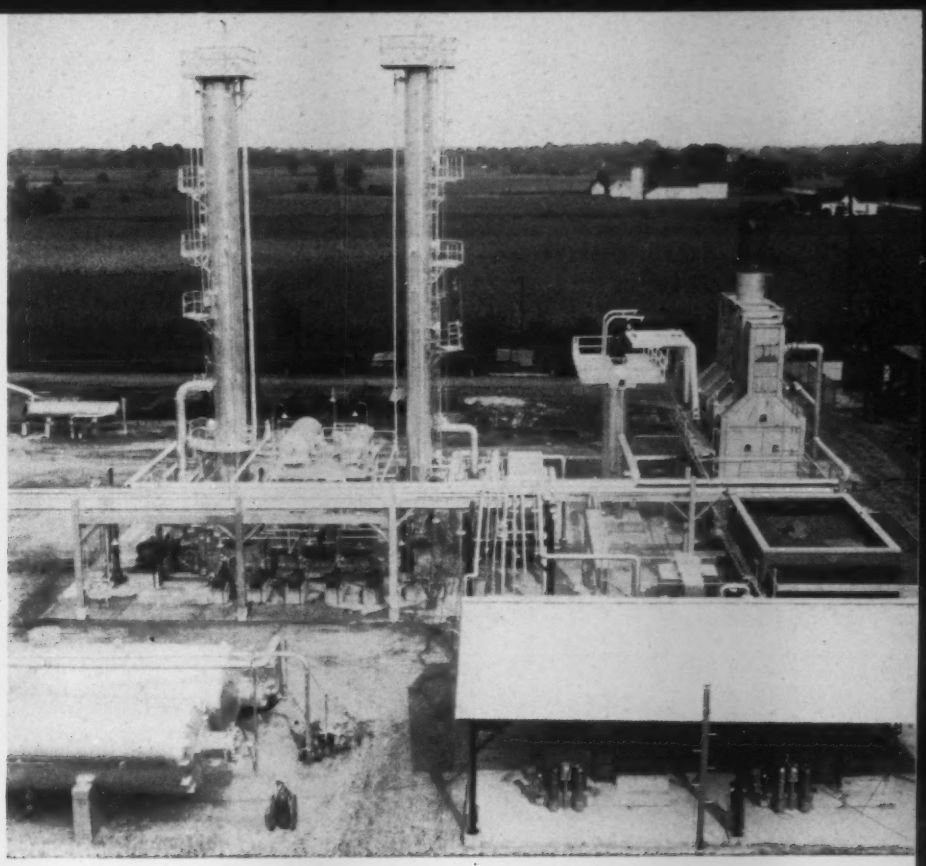
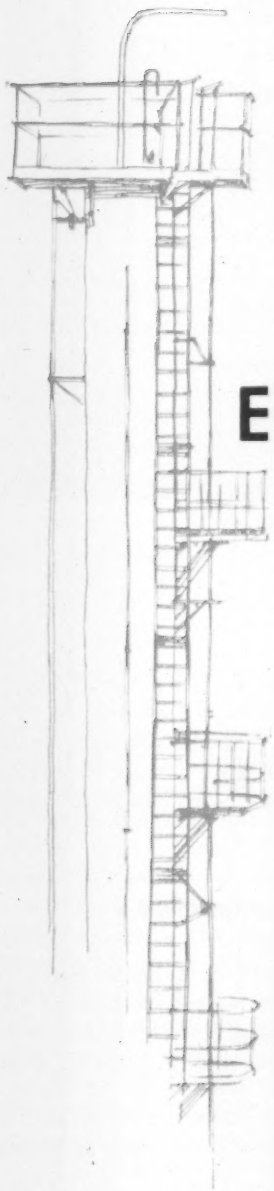


Fig. 1—Platforming unit at the Rock Island Refining Corp. Electronic controls provide regulation based on the rate at which the error is changing, or on a derivative function



ELECTRONIC CONTROLS REGULATE REFINERY

Here is the first complete refinery to be controlled by electronic instruments. Narrow "dead band" and rapid response indicate advantages in many process control applications

IN AUGUST 1949, the Rock Island Refining Corp. became the first in the world to put into operation a complete refinery controlled by graphic panel. This method of control has since been adopted by a majority of refiners for new units. In starting a new 2400 barrel-per-stream day unit recently at Indianapolis, Ind., *Fig.* 1, the company has maintained the distinction of pioneering in the field of process control. This new Universal Oil Products platformer, shown schematically in *Fig.* 2, is the first complete refinery unit in the United States to be controlled by electronic instruments.

Early Process Control

In the early days of process control, refineries were controlled by hand valves manipulated by an operators who checked a few thermometers and pressure gages. First improvement was a valve actuated by a rubber diaphragm opposed by a spring. Pressure on

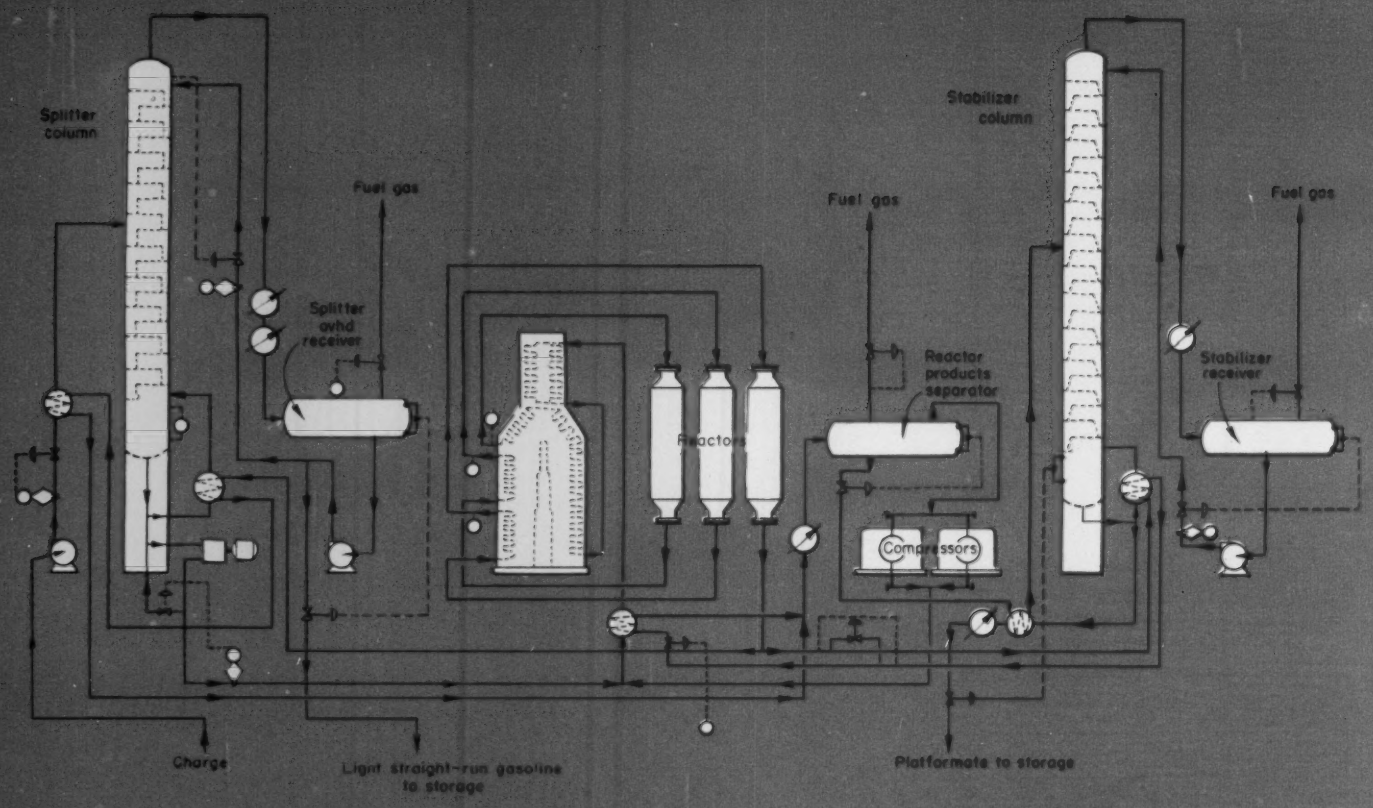


Fig. 2—Simplified flow sheet of the platforming unit tracing the petroleum charge through fractionating columns and reactors to end products. Note similarities in layout with the graphic control panel

diaphragm would cause the valve to move one way, the spring would cause it to move the other. Process pressure, then, was used to move the valve, achieving a small degree of automatic control. Later, a bulb containing volatile material was placed in the process stream and vapor pressure generated by process heat was used to move the valve, resulting in a simple form of temperature control.

As refineries grew larger and more complex, sizes of control valves increased, and such simple control methods no longer were adequate to obtain proper valve operation. An air relay added to the system, and piloted by the pressure or temperature measuring element, provided compressed air control of the valve diaphragm. Thus, greater force for operating the valve tended to minimize the dead band caused by mechanical sticking. This principle of the modern pneumatic controller has been widely adopted in process control.

Earlier controllers were merely indicating instruments, but later recording pens were added to the measuring element so that the operator was provided with a record of process variables, as well as automatic control of them. These recording instruments were located at the point of measurements and control. Later, they were moved to a centralized control room so that the operator could obtain an overall picture of a particular operation from one point, enabling him more easily to interrelate the various readings.

▶ Graphic Panel Instrumentation

With the continued growth of process units, it was found that serious lags were occurring in the control system because of long lines required from points of measurement and control to and from the control room. Graphic panel type of instrumentation was developed to correct this situation. The one designed for this new platformer is shown in *Fig.* 3.

This system permitted the recording and indicating functions to be divorced from the metering and control systems so that these could be located at the point of control. Yet the operator in the control room could record and adjust the controller's set point, thus making for a faster and better control system without sacrificing any benefits of a

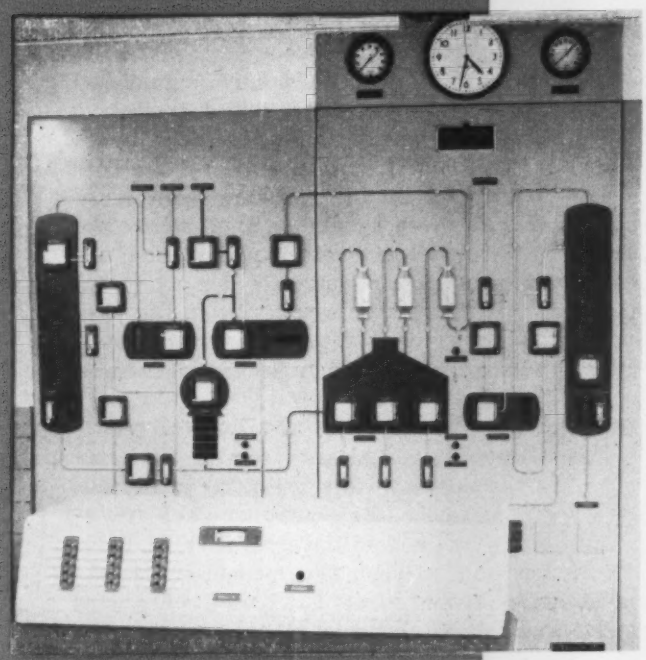


Fig. 3—Graphic control panel separates recording and indicating functions from metering and control. Set points may be adjusted from the control room

centralized control system. Secondly, the smaller size of this type of instrument made it ideal for use in a graphic representation of the plant schematic flow diagram, permitting the operator to see at a glance the relationship of one controller to the other. The third advantage was use of a force-balance type controller which balanced air pressures instead of requiring mechanical movement of parts. This feature further tended to reduce the dead band with the result that instruments were more sensitive to small changes in the controlled variables.

Up to this point, all transmission of the measured variables and control functions was done by air pressure. However, handling of instrument air under conditions of low temperatures proved to be expensive and troublesome, especially in cold climates. It became necessary to use air driers to remove moisture which condensed in tubing and to use nonlubricated air compressors to prevent the desiccant from becoming coated and small passages from becoming plugged up. The pneumatic control system also suffered an additional disadvantage in the expense of installing and maintaining numerous small air lines running back and forth from the process unit to the control room. These lines were vulnerable to mechanical damage and required careful support.

▶ Modern Electronic Control

In the electronic type of control system, all transmission of measurement and control functions to and from the control room is electrical, making it no longer necessary to run air lines from the process unit to the control room and back again. These are replaced by conduit, *Fig.* 4, laid in a pipe rack which supports the process piping or may use the same conduit required for the light and thermo-

Fig. 4—Air line tubing is replaced by conduits at the refinery control house. Transmission of electrical signals rather than air pressure signals has eliminated the problem of cold weather freezing

couple lead lines already installed in the plant.

The electronic control system such as is now in operation at Rock Island requires air to move the valves. Electropneumatic converters used for this movement of the valve can be fitted with a small electric heater which will keep the air pilot used in the control system warm and prevent its freezing in cold weather.

Operating experience gained so far at Rock Island has proved that electronic control instruments have an even smaller dead band than was noted in pneumatic instruments because of increased sensitivity in measuring and control circuits.

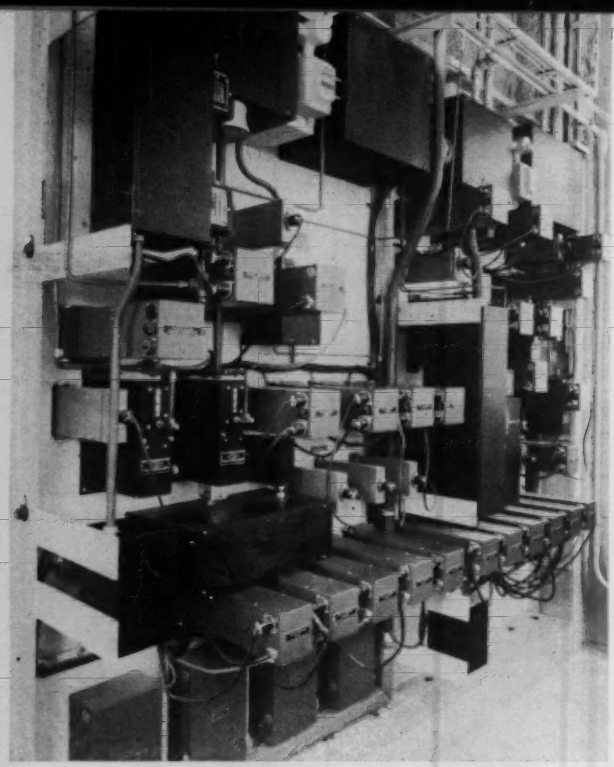


Fig. 5—Back of the graphic control panel for the platforming unit showing electronic instruments. Plug-in replaceability simplifies maintenance

Until recently, the majority of controllers in use were of the proportional-plus reset type. This meant that they biased the signal to the control valve based on two factors. The proportional control function is, as its name implies, proportional to the error that exists between the measured variable and the value set up by the operator. The so-called reset function is actually an integration with respect to time of the error that exists in the two values. The longer an error exists, the greater will be the corrective action sent to the valve.

A third control function is being incorporated into most temperature controllers today where more accurate control is desired. This is the so-called derivative function based on the rate at which the error is changing. If the error suddenly increases, it will make a much greater correction to the control valve than if it changes slowly.

Normal design of a thermocouple type temperature controller has not permitted optimum use of the derivative function because there usually is a mechanical means of balancing the potentiometer circuit in order to convert the electrical impulse to a pneumatic control impulse and to provide a record. It is possible that the process temperature may change slowly and will not be detected by the mechanical balancing mechanism until it is fairly large. Then it will suddenly accelerate, causing the derivative unit to sense a sudden change and make a large correction to the valve which could upset plant operation.

With the electronic control system, it is not necessary to interpose the mechanical balancing step to convert the electrical thermocouple signal to a control function. The electrical control signal has greater sensitivity, which results in giving a much truer picture of any rate of change in the process.

At the Rock Island installation derivative settings have been adjusted to rates that were never thought practical before on similar applications because of the distorted rate of change picture obtained. By being able to use greater derivative action and by having greater sensitivity in the controller, it has been possible to correct very small temperature changes before they became noticeable on the recorder.

A pneumatic control system compares the transmitted air pressure with an air pressure that has been set by the operator to correspond to the desired process variable. The controller then transmits a given air pressure to the control valve, holding it in position to keep the measured process variable at the desired value. Electronic controllers take the transmitted electrical signal and compare it with an electrical signal that has been set by the operator to correspond to the desired process variable. The controller then sends an electrical current to the control valve which, through an electropneumatic converter and a diaphragm head, holds the valve in a position that will keep the measured process variable at the desired value.

▶ Advantages of Electronic Control

Control board equipment at Rock Island was designed to simplify servicing. Each of the units was designed to plug into its own housing, *Fig.* 5. If one of the units needs servicing, the maintenance man has only to remove the unit and plug in a spare. All recorders and controllers are interchangeable.

Circuits are so arranged that the recorder is completely independent of the controller and vice versa. A breakdown in a recorder will not affect control of the plant, nor will a breakdown in a controller affect the record of the process variable. Circuits are so arranged that a power failure will cause the valve to assume the same position that it does on air failure.

While electronic controllers are based on the same principles as pneumatic controllers, they will be found superior in process control for these reasons:

(1) More reliable in cold climates.
(2) Eliminate the need for tubing racks with their high costs and maintenance problems.
(3) Better control due to their greater sensitivity or narrow dead band.
(4) Greater use of the derivative control function because they lack the tendency to distort measurement of the process variables rate of change.

With the foregoing advantages, electronic process controls cannot help but command greater application in future process control installations.

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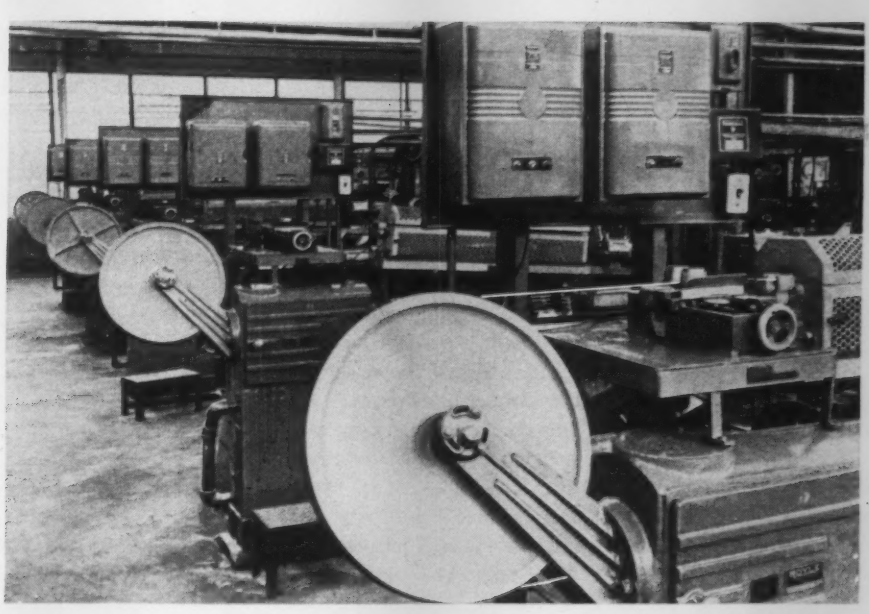
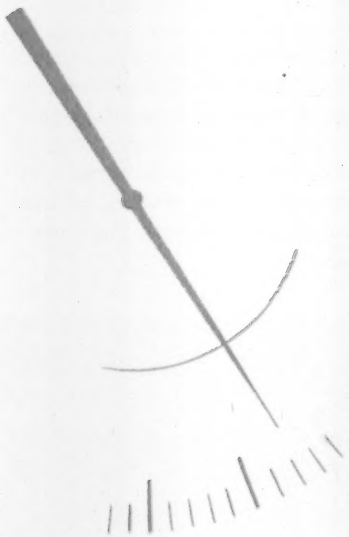


Fig. 1—Continuous processing control of thickness of insulation extruded onto wire is maintained by gage with measuring device between spark tester and take-up capstan signalling panel-mounted control boxes which actuate the corrections



AUTOMATIC IN-PROCESS GAGING

Part one of a series, this article introduces the subject and discusses continuous machine control gaging. Subsequent articles will cover cyclic processing and process control

INSPECTION FULFILLS a definite need in every well run plant not only to insure proper assembly of components but to maintain the customer's good will and respect for the quality of the product. For many years it has been the dream of managements who have felt that many dollars have been wasted on inspection, to eliminate the need for inspection or to find less expensive means of performing the operation.

Accurate linear measurements are as important to mass production as are the machines which actually produce the parts, *Fig.* 1. There is hardly any industry which does not use linear measurement to one degree or another. This ranges all the way from scale measurements such as used in structural work, where a 1/16-inch is considered a close limit, to the manufacture of gage blocks to a few millionths of an inch. Control of workpiece size on the order of a few thousandths or ten thousandths of an inch is absolutely necessary for volume production of interchangeable parts. Such items range from subminiature tubes, where a thousand or more turns of wire are wound on a form to make a grid, and still leave space between the wires, to larger components of earth moving equipment.

For various reasons machines do not produce parts of exactly the same size. If the manufacturing process is under control with a machine in good condition it is reasonable to expect that parts produced will be the same within small decimal limits. However, variations will be found from one piece to the next. This is caused by many factors, among which are machine age, condition, basic rigidity of the machine, amount of work done, and material variations. With a machine in

good condition, the average size of parts produced will gradually change as affected by operational changes. Repetitive measurements are necessary when starting the operation to determine that the parts are close to the correct size and to see that the average remains close to this nominal size.

In many instances it is possible to hold quality levels to predetermined percentages by means of statistical quality control systems. However, where the quality of incoming materials or parts, number of parts and variety of vendors requires the taking of large samples, an appreciable amount of money may be spent on inspection labor. Where the individual parts are expensive, as would be the case of an aircraft engine housing, the expense of measuring the various dimensions is small compared to the value of the part.

However, where parts are mass-produced and the individual pieces are worth a few cents or less, such individual inspection costs cannot be tolerated. In cases like this, the cost of hand inspection may well exceed the original cost of the piece. On such relatively inexpensive pieces, it is profitable to measure and sort on an automatic basis. In many plants such automatic measuring devices are accepted as a part of production tooling setups, just as necessary as production machinery.

An automatic gaging device performs essentially the same function as an operator who picks up a part, positions it, measures it with micrometers or comparators and places it into a correct container. The important differences are that the automatic gage performs at a much higher rate of speed with greater accuracy, absolute impartiality and most important, without any fatigue factor. An automatic gage is therefore a machine designed to do inspection of certain parts on a production-line basis without the necessity of many operators.

Types of Automatic Gaging

There are three main types of gages which fit into this category of automatic inspection. Each of these categories can be further subdivided.

First and most logical of the three main types of automatic inspection devices is that type of gage which mounts onto the producing machine and becomes in effect, a part of, and the master of that machine. This gage actually measures the work-

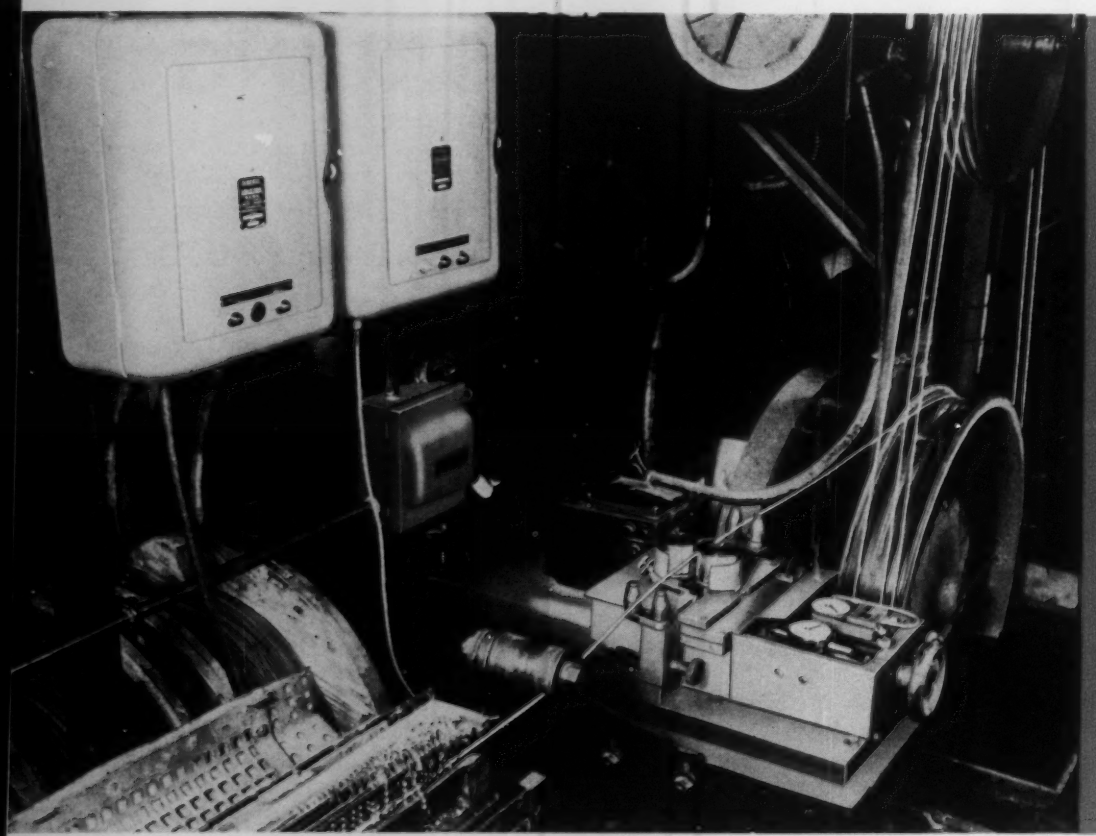


Fig. 2—Close-up view of installation similar to *Fig.* 1 showing reference roller and sensitive measuring roller. Signal lights on control boxes indicate oversize, good, and undersize and whether or not the control is making a correction

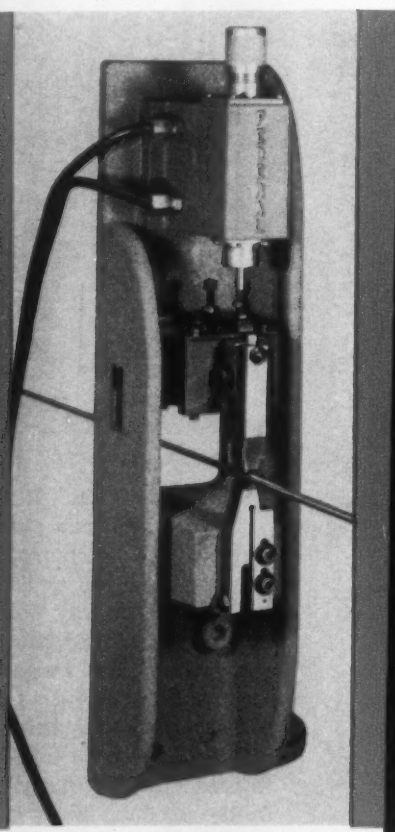


Fig. 3—Gaging head which when mounted on the exit side of a centerless grinder constantly measures the work and signals the controller

piece while it is in process and controls the production tools so that nothing but good work is produced. Typical operations suitable for this type of control would be continuous plastic extrusion, through-feed centerless grinding, parallel disk griding, centerless plunge grinding, external cylindrical grinding, internal grinding and certain types of lathe work.

Other types of operations, such as on screw machines and punch presses, are not suited for this type of product control. Due primarily to lack of space, it is almost impossible to get gaging devices into contact with the work while it is being produced with these processes. In such applications the gage fits into the conveyor line immediately after the individual manufacturing process, much as though it were another production machine. Each and every part manufactured is inspected for the particular operation before being permitted to continue to the next operation. This type of gage can also take complete control of the process. It is true that the gage is always measuring one piece while the succeeding piece is being manufactured but very close control can be established even with this method.

Gages of this type have been equipped, for example, with percentage counters. These allow a certain percentage of defects which the gage culls out from a particular operation. If this percentage is exceeded, the gage shuts down the entire process.

The third main type of product control involves the use of a completely separate automatic gaging machine. This is generally considered to be a separate inspection function applicable in cases such as with incoming parts from vendors. With this type of equipment a product produced in one locality is moved to the gage location and sorted into good and bad, hours even days after manufacture. This area of gaging is outside the scope of this presentation and will not be covered in this article.

▶ Continuous Wire Processing

One of the first successful machine control applications was gaging and controlling continuous extrusion of plastic onto copper wire. In the manufacture of insulated electric wire it is necessary that the coating thickness be maintained at a certain minimum. If the coating becomes too thin, the wire fails to pass Underwriter's Laboratories tests and is rejected material. To avoid this condition it was formerly the operators practice to run the extrusion process providing a heavier than necessary coating thickness, to meet this minimum

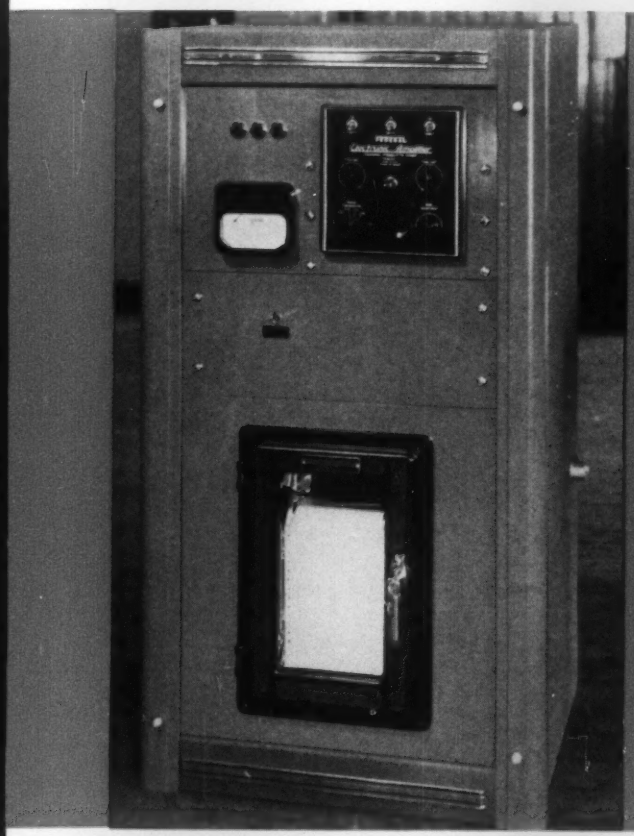


Fig. 4—Electronic unit contains amplifier to interpret the signal from the gage head and transmit the information to the classifier (a series of thyratrons) which in turn operates signal lights and controls machine. Recorder provides continuous running record of work size

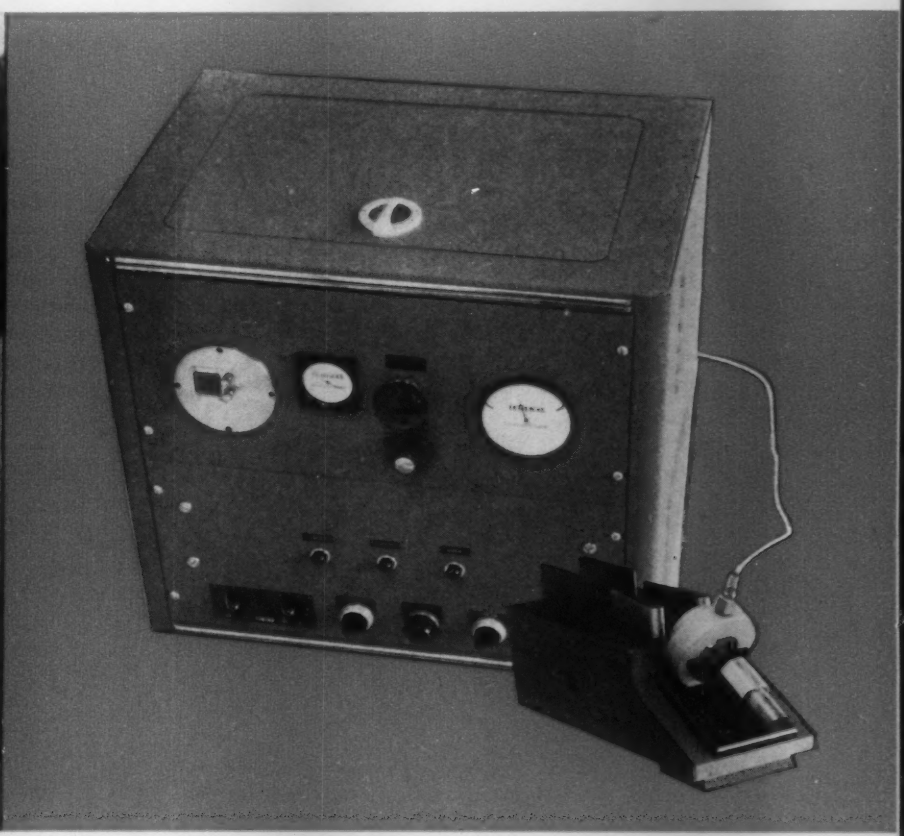


Fig. 5—Air-electric gage ring for centerless grinder mounting signals part size to the control unit which moves deflectors in disposal chute to divert oversize and undersize parts from the flow of good workpieces

standard. This resulted in a waste of material. Contrary to popular belief the largest wastage occurs on the smaller rather than on the larger size wire. A difference of 0.001-inch in excess stock thickness on No. 18 solid wire, which can be coated at the rate of about 30,000 feet an hour, results in a loss of about $5,000.00 in the course of a year.

It is physically impossible for an operator to manually check the size of the wire accurately while it is moving, and it is unreasonable to expect him to check the wire more than once every 15 minutes. A machine control gage can check the wire all the time it is running and make adjustments to the machine as frequently as necessary.

The gage and its associated control boxes, which are shown in *Figs.* 1 and 2, are mounted in the pass line of the wire, usually immediately after the waterbath and ahead of the take-up-capstan. The gage rollers are in constant contact with the OD of the wire. One roller serves as a fixed reference and the other as a sensitive or measuring roller. An electrical signalling device follows the movement of the sensitive roller and transmits the intelligence to the first power unit or control box. This unit is equipped with built in time delay which causes it to overlook the purely local bumps or low spots in the wire and measure the average wire size. When the average wire size approaches one of the preset limits, control box No. 1 transmits an out of tolerance signal to control box No. 2. The second control box jogs the take up capstan to either speed up or slow down wire drawing speed as necessary to correct wire size. The length of this jog is calculated to be sufficient to correct wire size in increments of about 0.0005-inch.

After the correction has been made the second control box performs the additional function of shutting off the entire gaging operation until sufficient time has elapsed for wire which was made after the correction to reach the gage. The entire gage is again turned on automatically and remeasures the wire. If the second correction is necessary it is made and the entire process repeated. When the gage is satisfied that the wire is within limits it does not adjust the machine, but it does signal the operator by means of a green light that the process is under control.

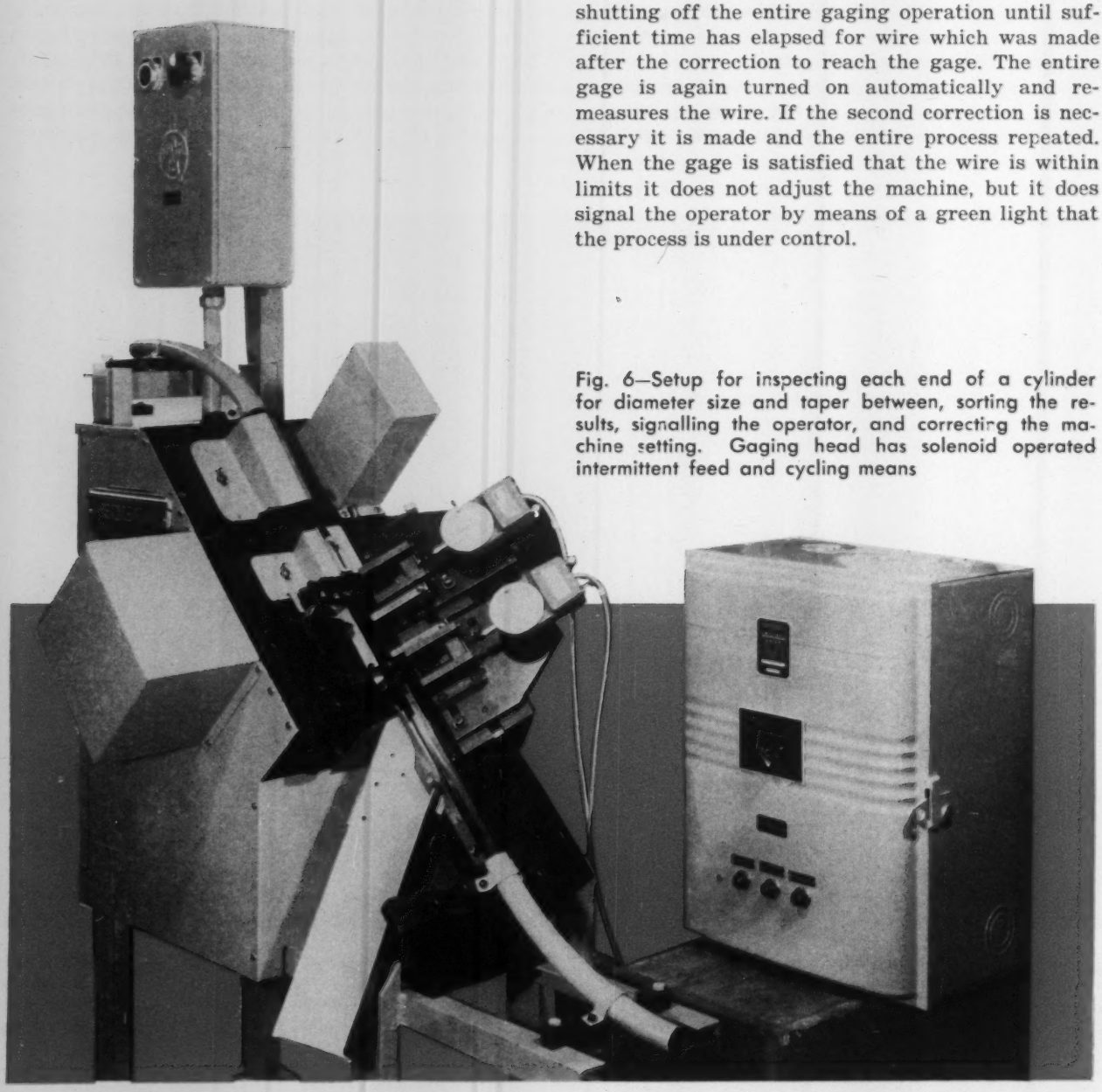


Fig. 6—Setup for inspecting each end of a cylinder for diameter size and taper between, sorting the results, signalling the operator, and correcting the machine setting. Gaging head has solenoid operated intermittent feed and cycling means

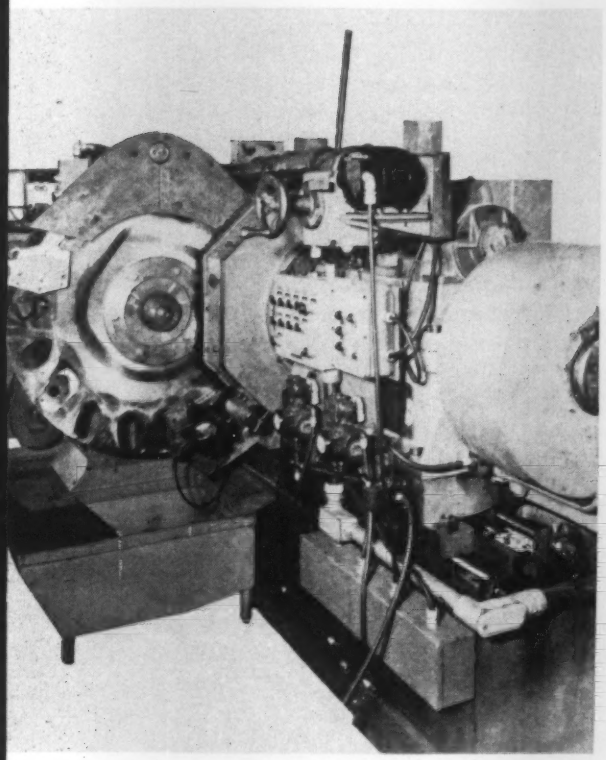


Fig. 7—Parallel-disk grinder equipped with gaging head on transfer feed wheel. Wheel is loaded at left, rotates clockwise between grinding disks and gaging head, then unloaded

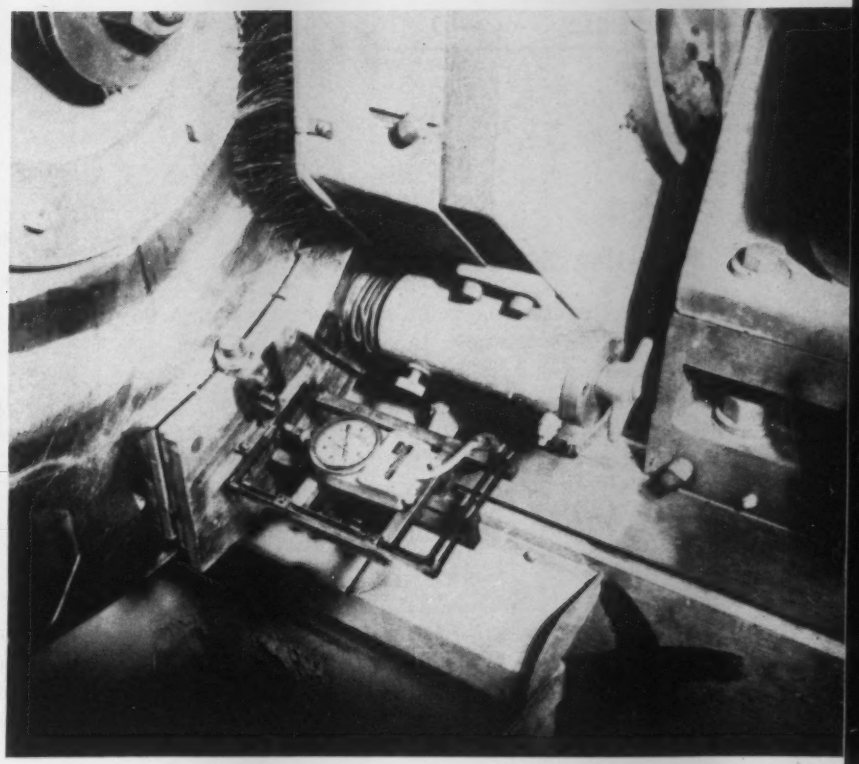


Fig. 8—Gaging head of the installation pictured in *Fig.* 7 measures thickness of outcoming parts and initiates correction which jogs left and right-hand grinding heads alternately into the proper grinding size

▶ Centerless Grinding Control

In the metal working field through-feed centerless grinding most nearly approaches continuous processing such as that of the wire coating process described. In the usual multiple machine setup, pieces pass through the grinder and continue by means of a conveyor onto succeeding operations. The entire process may well be likened to extrusion and the fact that individual pieces are being manufactured may be ignored.

In cases such as this, the gage shown in *Fig.* 3 can be mounted on the exit side of the centerless grinder. The gage then will furnish the operator with a continuous running account of the condition of the process. This particular gage is arranged for mechanical contact with the workpieces. The gage mounts on the through-feed work-rest immediately after the grinding wheel, in such a manner that each and every part passes between the gage contacts (immediately after grinding). The sensing head (Electricator) measures each and every piece that comes from the grinder and transmits a signal to the control unit. The control unit is arranged with electrical damping so that it tends to measure the average size of the workpieces meanwhile overlooking purely local conditions such as slots, grooves, or chamfers at the ends of the pieces. When the average size tends to approach either the high or low limit, a signal is transmitted for the necessary correction.

Where extremely close accuracies are required, the same type of gage has been furnished with an electronic gage head, a suitable amplifier, a classifier which will furnish several sets of signals to the grinding machine, and a recorder, *Fig.* 4. With this type control we have what almost amounts to a closed circuit arrangement. The gage measures the average size of the workpieces and provides a running record of this size. The classifier is equipped with four limits. The two limits closest to nominal size of the workpiece are used to correct the machine as the wheels wear or the machine drifts due to temperature changes. The two outside limits can be used to shut off the machine, provide visual or audible signals, or used to make major corrections in the machine.

In normal operation only the two limits nearest nominal size will come into action. These will compensate for the normal wheel wear and drift of the machine. If either of the two outside limits operates it means that the process is completely out of control and that drastic steps are necessary. One customer, who has used this type equipment, and mounted it on a centerless grinder to which he has done some conversion work, reports

that it is possible to hold size within 30 millionths of an inch.

Sorting the Controlled Output

In some centerless grinding operations it is desirable to actually sort the parts as well as provide signals for machine corrections. One application of this type of control is the grinding of small pistons such as are used in shock absorbers or power steering mechanisms. These pistons have a diameter of about one inch, and a length of about ¾-inch. As they go through the final pass of the centerless grinder practically no stock is removed. As a result there is very little forward workpiece thrust on the exit side of the machine.

In this case it was deemed desirable not to use the contact type gage, but rather an air ring sensing head which would not impede the forward motion of the parts. The air ring was provided with about 0.003-inch clearance over and above the maximum size piece expected. The air ring is mounted on the exit side of the centerless grinder in the pass line of the work. Immediately after the air ring a disposal chute is mounted. The air ring is tied in through an air-electric head, *Fig.* 5, to a powder unit similar to the ones previously described.

Again, the air unit is equipped with damping to cause it to overlook chamfers at the beginning and end of each part. As each part passes through the ring an electrical signal is transmitted by the air-electric head to the control unit. If even a single piece is found to be undersize or oversize, the correct disposal chute is energized diverting the defective piece or pieces. With a continuous process such as this it is not practical to try and obtain control of each and every piece. Therefore when the disposal gate operates to reject a piece one or two good pieces may go along with it.

This method insures that all those pieces which continue on to subsequent processing are good. The fact that a few good pieces end up with the defectives is not considered objectionable.

When grinding certain types of parts on a through-feed centerless operation it may be desirable to check every part for several characteristics, such as diameter at each end, taper and hardness, in addition to signalling the operator and/or controlling the machine. One gage of this type is shown in *Fig.* 6. This type of gage mounts on the floor as close as possible to the exit side of the centerless grinder.

Each part leaving the centerless grinder enters a temporary storage area in the gage. As soon as the gage is clear of the preceding part, the gage cycle starts. The storage area gate is opened, the piece leaves the storage area, moves ahead a little more than its own length into a gaging area. The gage heads can either be in position or can come down from above and take the various required measurements. The signal or intelligence from these gage heads is transmitted to the disposal chutes and also to the signal lights or machine controls. After a fraction of a second, just long enough for the gage to obtain its measurement, another gate opens permitting the part to leave the gaging area and descend towards and through the correct disposal trap and chute.

A gage of this type performs the double function of actually sorting acceptable from reject pieces, as well as signalling the machine. This gage can easily handle up to 5000 parts per hour. This is adequate to keep up with practically all centerless grinding operations where such measurements and control might be desirable.

Parallel Disk Grinding

In parallel disk grinding, either with a transfer wheel or with the through-feed chain, the process is somewhat similar in principle to centerless grinding. A gage such as shown in *Figs.* 7 and 8 can be applied to either of these types. These illustrations show the gage applied to a feed wheel type of operation. The gage mounts in a position to measure the work after it has passed between the grinding wheels. The gage itself is provided with a pair of contacts so that it actually touches both sides of the work, and is not influenced by run out or variations in the transfer wheel.

For those cases where the work is clamped into the wheel the gage is arranged to float and follow the actual thickness of the material. The gage shoes are usually, though not always, made long enough to span several workpieces. By doing this the gage overlooks the gap between the pieces. This is not absolutely necessary. Cycling switches can be provided so that the gage is energized only by the presence of a piece of work.

By measuring over several workpieces the gage tends to average out the size. When the work is found to be approaching the tolerance limit a signal is sent to the grinder, causing, let us say, the left-hand wheel to index for a correction. The gage then shuts itself off waiting for new pieces to come along. Based on the time cycle the gage re-energizes itself when new pieces arrive. If a second correction is necessary the opposite wheel is energized.

The measuring and alternate wheelhead corrective cycle is repeated until the gage is satisfied that the workpieces are to size. Making alternate corrections to the left and right-hand wheels tends to keep the carrier or transfer disk centered between the grinding wheels. This helps prevent the grinding wheels from running into the transfer disk. The gage can also decide after a predetermined number of corrections within a given time that the process is out of control. At this point the machine is shut down and a visual or audible signal warns the operator.

Next article of this series concerns automatic production gaging of cyclic processing and will appear in the next issue.

Fifth of a series, AUTOMATION presents another section of the ASME standard "Automatic Control Terminology"; an original work of the Terminology Committee of the Industrial Instruments and Regulators Division. It is hoped these data sheets will assist in furthering the adoption of a standardized language in the field of automatic control.

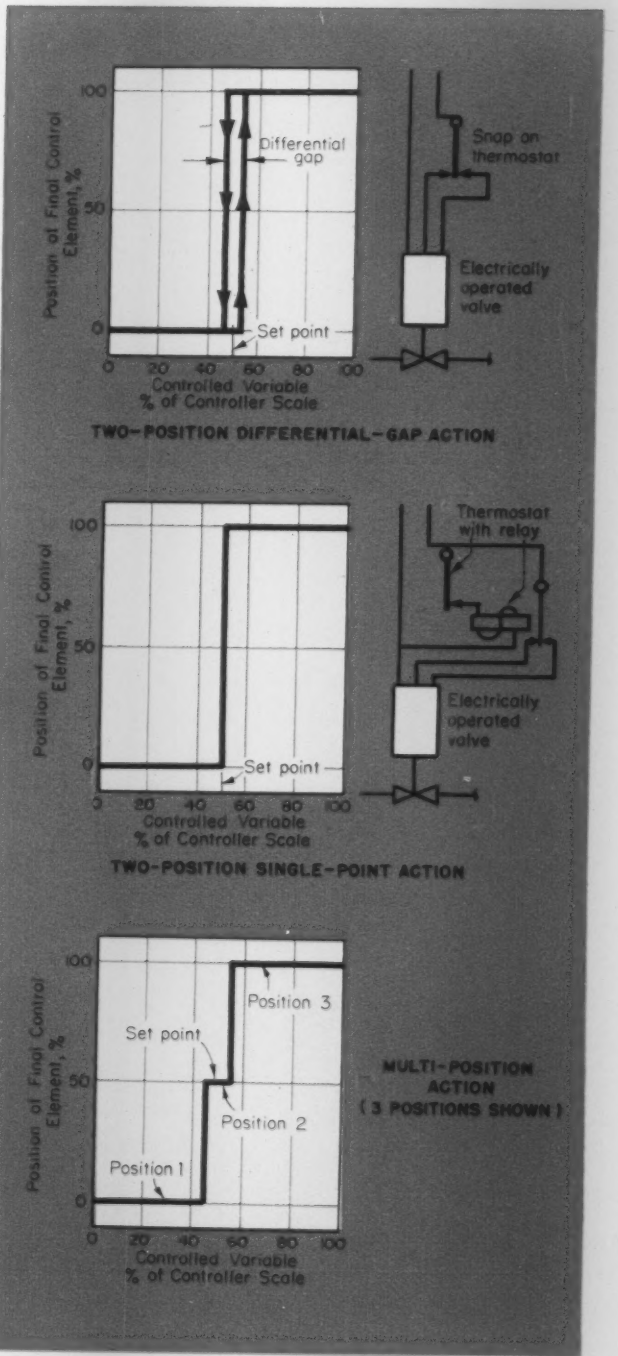
TYPES OF CONTROLLER ACTION

FOR SIMPLICITY, the definitions which follow are stated in terms relating controller action to "position of a final control element". However, these definitions are not intended to be restrictive and apply equally to equivalent controller action related to (1) "value of the manipulated variable", and (2) "value of set point of another controller".

For types of automatic controller actions which are defined as having a linear relation between a function of the controller variable and position or rate of motion of the final control element it is assumed that the linear relation may be referred to, (a) "either motion or force of the last element in the measuring means", as well as to, (b) "value of the controlled variable".

It is assumed that the automatic controller is capable of detecting infinitesimal variations of the controlled variable. The definitions and diagrams apply either to the instantaneous response of an idealized controller or the ultimately balanced state of the actual controller.

NOTE: The set point is shown at 50 per cent of scale in a number of the following diagrams with no implied significance—it may be located anywhere along the scale.



501. POSITIONING ACTION is that in which there is a predetermined relation between the value of the controlled variable and the position of a final control element.

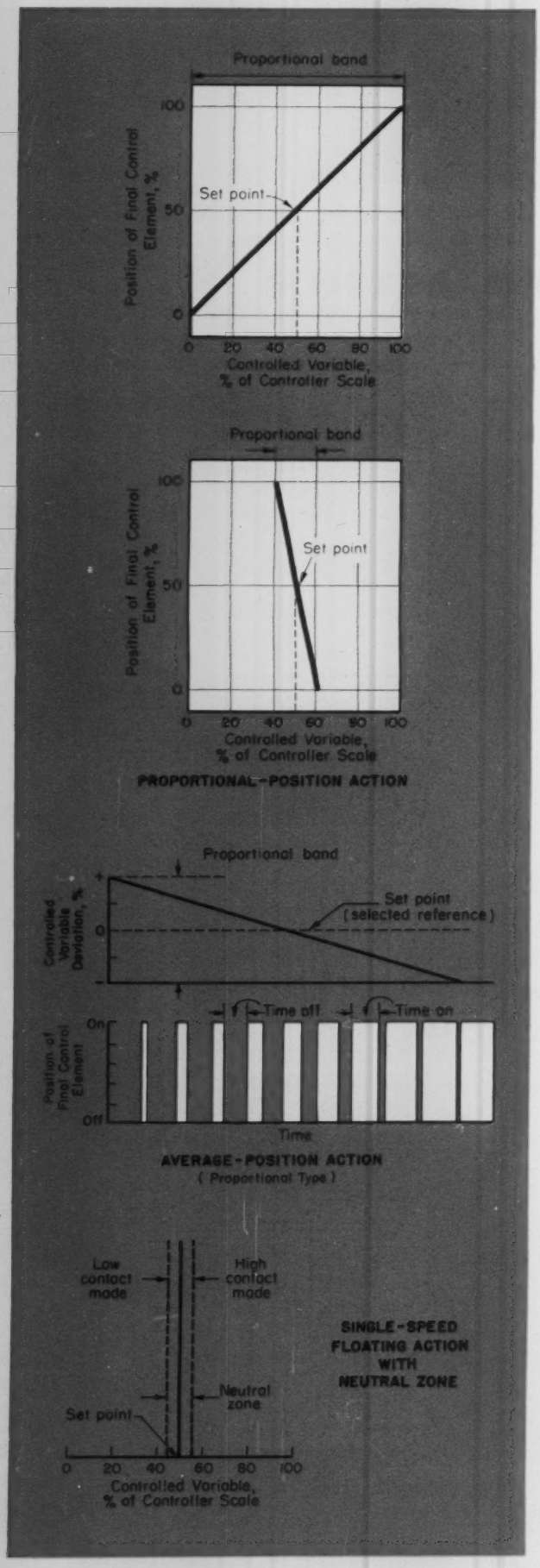
501a. TWO-POSITION ACTION is that in which a final control element is moved from one of two fixed positions to the other.

"Open and Shut action" and "On-Off action" are synonymous terms.

TWO-POSITION DIFFERENTIAL-GAP ACTION is that in which a final control element is moved from one of two fixed positions to the other when the controlled variable reaches a predetermined value from one direction, and subsequently is moved to the first position only after the variable has passed in the opposite direction through a range of values to a second predetermined value.

TWO-POSITION SINGLE-POINT ACTION is that in which a final control element is moved from one of two fixed positions to the other at a single value of the controlled variable. The differential gap of this type of two-position action is zero.

501b. MULTIPOSITION ACTION is that in which a final control element is moved to one of three or more predetermined positions, each corresponding to a definite range of values of the controlled variable.



501c. PROPORTIONAL-POSITION ACTION is that in which there is a continuous linear relation between the value of the controlled variable and the position of a final control element.

501d. AVERAGE-POSITION ACTION is that in which there is a predetermined relation between the value of the controlled variable and the time-average position of a final control element which is moved periodically from one of two fixed positions to the other.

This controller action is similar to two-position action in which the percentage "time-on" of the final control element is dependent upon the value of the controlled variable. The percentage "time-on" may have either a fixed or infinite number of values to correspond to any one of the other positioning-controller actions defined previously.

502. INTEGRAL ACTION is that in which the final control element is positioned in accordance with a time integral function of the controlled variable.

Floating action is the most common form of integral action.

502a. FLOATING ACTION is that in which there is a predetermined relation between the deviation and the speed of a final control element.

A neutral zone, in which no motion of the final control element occurs, is often employed in floating controller action.

SINGLE-SPEED FLOATING ACTION is that in which a final control element is moved at a single speed.

MULTISPEED FLOATING ACTION is that in which a final control element is moved at two or more speeds, each corresponding to a definite range of values of deviation.

PROPORTIONAL-SPEED FLOATING ACTION is that in which the final control element is moved at a speed proportional to the deviation.

RESET ACTION is that in which the final control element is moved at a speed proportional to the extent of proportional-position action. This term applies only to a multiple action including proportional-position action.

FLOATING-AVERAGE-POSITION ACTION is that in which there is a predetermined relation between deviation (of the controlled variable) and the rate of change of the time-average position of a final control element which is moved periodically from one of two fixed positions to the other.

503. DERIVATIVE ACTION is that in which there is a predetermined relation between a time derivative of the controlled variable and the position of a final control element.

The most common form of derivative action is first derivative or RATE ACTION.

503a. RATE ACTION is that in which there is a continuous linear relation between the rate of change of the controlled variable and the position of a final control element.

This controller action maintains a linear relation between the first derivative or the rate of change of the controlled variable and the position of a final control element. This identical controller action may also be considered as maintaining a linear relation between second derivative or rate of the rate of change of the controlled variable and rate of motion of the final control element.

504. MULTIPLE ACTION is that in which two or more controller actions are combined.

PROPORTIONAL PLUS FLOATING ACTION is that in which proportional-position action and floating action are combined.

PROPORTIONAL PLUS PROPORTIONAL - SPEED FLOATING ACTION is that in which proportional-position action and proportional-speed floating action are combined.

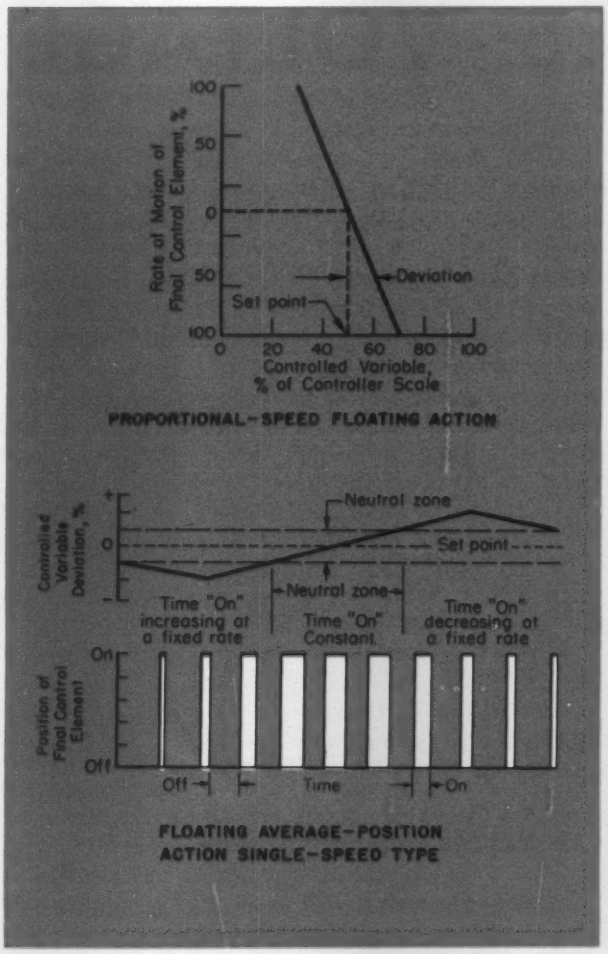
PROPORTIONAL PLUS RESET ACTION is that in which proportional-position action and reset action are combined.

PROPORTIONAL PLUS RATE ACTION is that in which proportional-position action and rate action are combined.

PROPORTIONAL PLUS RESET PLUS RATE ACTION is that in which proportional-position action, reset action, and rate action are combined.

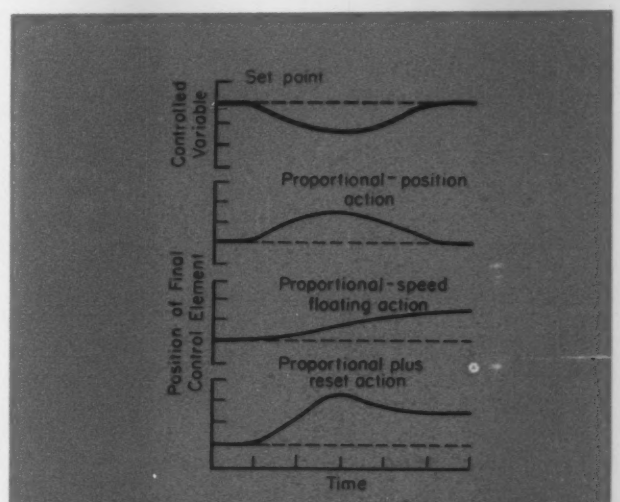
505. SAMPLING ACTION is that in which the difference between the set point and the value of the controlled variable is measured and correction made only at intermittent intervals.

Sampling action may be employed in any of the previously listed controller actions.

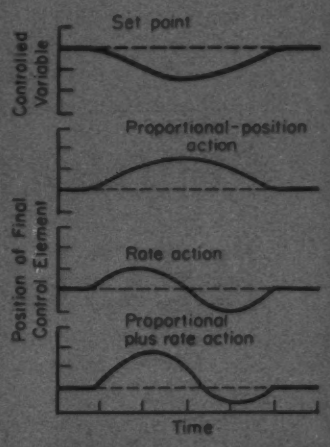


PROPORTIONAL-SPEED FLOATING ACTION

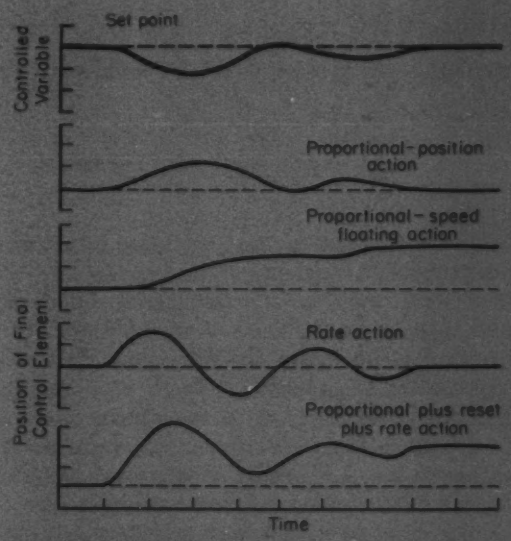
FLOATING AVERAGE-POSITION ACTION SINGLE-SPEED TYPE



PROPORTIONAL PLUS RESET ACTION



PROPORTIONAL PLUS RATE ACTION



PROPORTIONAL PLUS RESET PLUS RATE ACTION

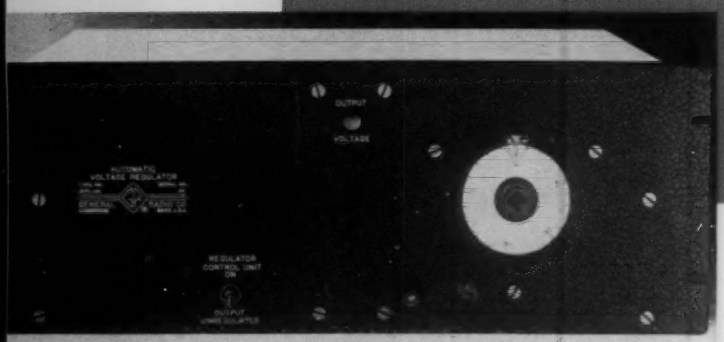


Fig. 1—Automatic voltage regulator panel has two controls: an on-off switch for the unit and an output voltage adjustment accessible with a screwdriver

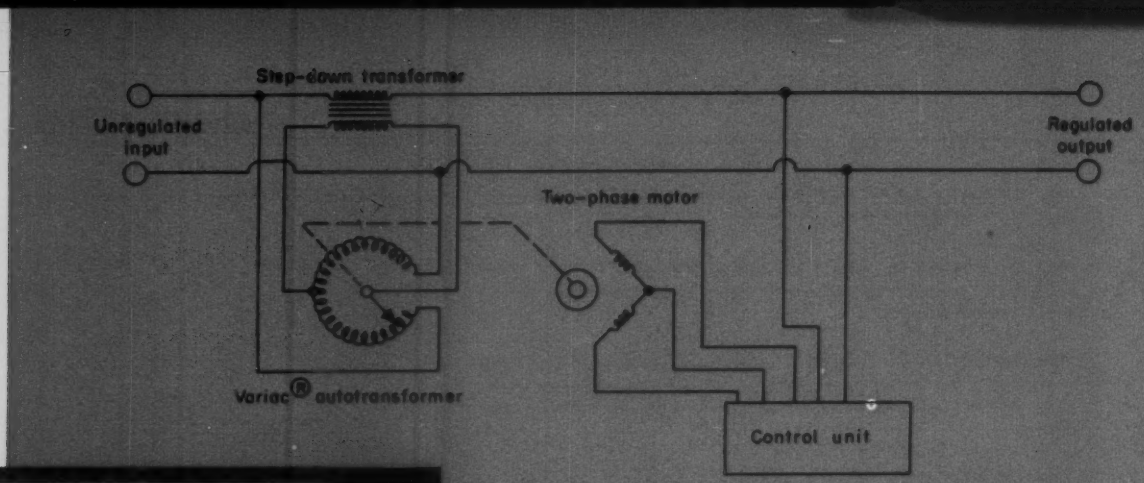


Fig. 2—Functional diagram showing the "buck or boost" circuit used as a means of control

FEEDBACK SYSTEM REGULATES VOLTAGE

By M. C. HOLTJE
Engineer, General Radio Co.
Cambridge, Mass.

This line-voltage regulator system for motor control demonstrates "classical" closed-loop control. All feedback components are used—reference input element, summing point, control element, and controlled system

STABILITY of ac line voltage is a primary requirement not only in precise laboratory measurement but, in the industrial plant where processes must be precisely controlled. While manual control is adequate for many purposes a completely automatic control system, eliminating the need for an operator, is more satisfactory.

Most automatic regulators use vacuum tubes, saturating core devices or mechanical systems as the regulating elements. For industrial and general laboratory use, the relatively high power rating required precludes use of vacuum tubes. The magnetic type using a saturable-core reactor as a series impedance, although fast-acting and economical in small sizes, requires a restriction on load power factor and distorts the output waveform.

For many applications, therefore, the mechanical regulating system is most suitable. An adjustable autotransformer and an automatically controlled motor drive—a regulator of this type—is inherently somewhat slower in response than the magnetic type but its speed is still adequate, it has high efficiency, no power-factor restrictions, and adds no harmonic distortion to the input voltage.

An automatic voltage regulator, *Fig.* 1, developed by General Radio Co. has accuracy of plus or minus 0.25 per cent, good transient response combined with 6KVA capacity, 98 per cent efficiency, and no distortion or power-factor restrictions. Basically, this regulator consists of a Variac® autotransformer that adjusts output voltage, a "buck-or-boost" step-down transformer that effectively multiplies the power rating of the Variac, and a servomechanism that positions the Variac.

Voltage Adjusting System

"Buck-or-boost" circuit used, *Fig.* 2, permits control of high-power circuits with a low-power Variac,

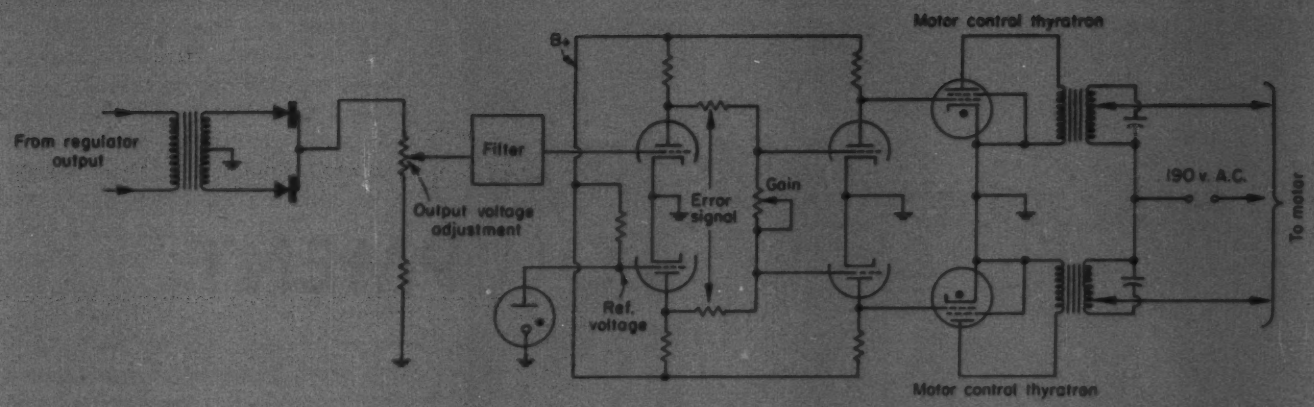


Fig. 3—In this control unit circuit, the regulated signal is compared to a reference standard to produce an error signal which controls a two-phase motor through motor control thyratrons

effectively multiplying the Variac rating. The auxiliary transformer uses multiple windings to provide either a plus or minus 10 or 20 per cent correction range at 115 or 230 volts.

Regulator performance is due in large part to the design of the control circuit for the two-phase servomotor. The system utilizes a proportional-control servomechanism, rather than the on-off type control often used, to provide better accuracy than would be obtained with relays. A low-inertia servomotor with dynamic braking gives good band width and transient response.

No power amplifiers are used to supply the motor control windings and motor power is obtained directly from the ac line. The control unit adjusts the phase angle between voltages applied to the two-phase armature and, thus, controls rotation of the motor. Design utilizing appropriate lead and lag networks results in high response speed, accuracy, and favorable overshoot characteristics.

▶ Control Circuit

An elementary circuit diagram of the control unit, *Fig.* 3, shows that the regulated output voltage is measured with an average-response full-wave rectifier to obtain a dc voltage proportional to the ac output voltage. The dc value of this rectified voltage is obtained by providing a resistive load for the rectifiers and filtering the ripple voltage. Use of a full-wave rectifier separates the undesired ripple frequency as far as possible from the pass band of the regulator. Ripple filter provides an infinite rejection at the 120-cycle ripple frequency, with negligible phase shift below 5 cycles per second. Germanium junction diodes, operate at high rectifier efficiency and minimize effect of rectifier characteristic changes.

This filtered voltage is compared with a standard from a voltage reference tube. The difference is the error voltage and is used ultimately to reposition the Variac. Amplified error voltage is applied in "push-pull" to a thyratron motor control circuit. Thyratrons are provided with a 60-cycle bias voltage at a 90-degree phase angle with respect to ac plate voltage. Amplified dc error voltage superimposed on this ac bias voltage smoothly changes the thyratron firing angle from near 0 to 180 degrees.

A two-phase motor is supplied with 60-cycle power from the power line through the thyratron control circuit. By variations in their firing angles, thyratrons control the relative phase angle between motor-winding voltages. Distorted output voltages are filtered with resonant circuits and applied to the motor windings, and as the thyratron firing angle changes from 0 to 180 degrees, the angle between the motor voltages changes continuously from approximately plus 90 degrees to minus 90 degrees. At balance, full voltage is applied to both motor windings at a zero-degree phase angle. Dynamic braking improves transient response.

▶ Accuracy Characteristics

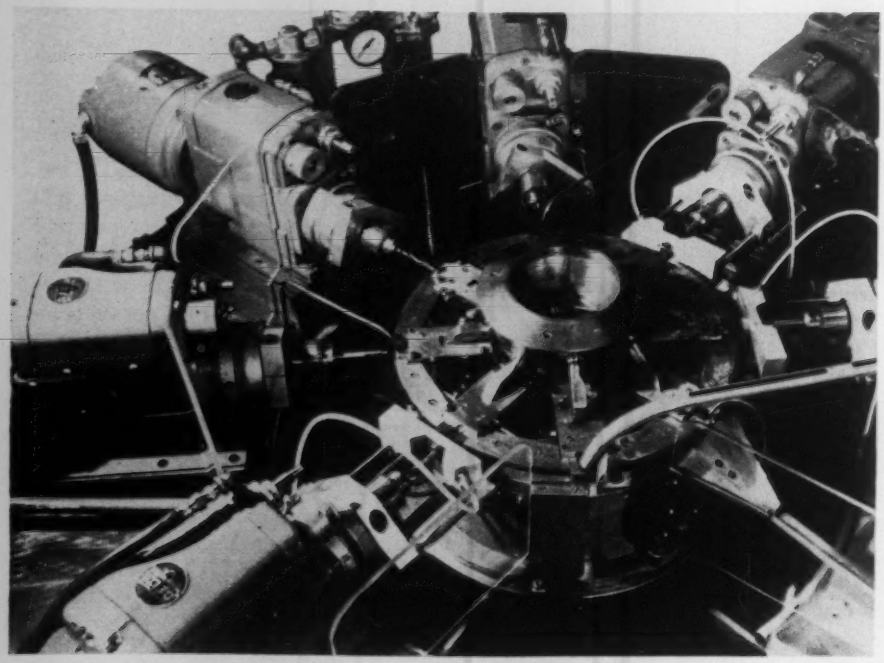
Motor torque is proportional to error voltage; any error voltage greater than that required to overcome frictional forces results in acceleration of the motor until the error is substantially eliminated. A limit on ultimate accuracy of control is imposed by the fact that the motor cannot reposition the Variac until its torque is greater than the small friction losses in the system. These have been reduced to the point where other factors, such as limitations in the accuracy of the voltage reference tube, the magnitude of the voltage steps from the Variac, and initial-electron-velocity effects in the input amplifier, would combine to prevent any substantial increase in accuracy.

AUTOMATION

NEW EQUIPMENT

Machines and plant equipment designed for more automatic operation

SLIDING SUB-BASE FOR AUTOMATIC DRILLS



As part of a program to standardize elements of special purpose machinery and thus reduce their cost, a line of sliding sub-bases has been developed for standard air-hydraulic drill units. With these bases, drill units which are built into special machinery can be moved forward or backward with relation to the parent machine without loss of machine alignment. This facilitates removal and replacement of tools, and saves time in making setup adjustments while preventing any machine misalignment. Three bases are available, one for each size of company's drill units, with length of travel 4⅛-in. in the small model and 6 in. in the two larger units. **Drill Unit Div., Rockwell Mfg. Co.,** 434 N. Lexington Ave., Pittsburgh 8, Pa.

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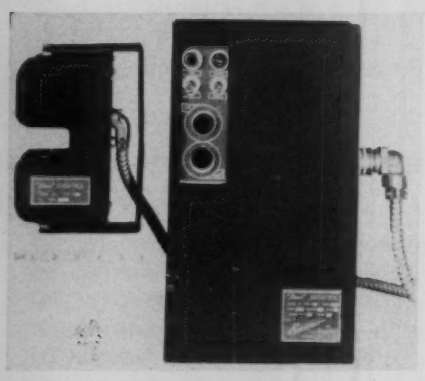

PHOTOELECTRIC GUIDER

Photo-electric edge guider eliminates visual or manual supervision in many handling and processing operations, as well as preventing material waste due to control inaccuracies for textile, paper, rubber, and plastics plants. Known as the Linar Edgetrol, the device has a recessed control panel and a wide sensing-head slot. Since no force of any kind is applied to the material, accurate edge registration of very light or thin, as well as heavy materials is possible even when no tension is present. Rapid response of the guider results in overall accuracy of 1/32-in. or more at high linear speeds up to 60 actuations per minute. Cast aluminum swiveling head is designed for easy mounting and adjustment. Self-contained reversing contactor permits use with standard tenter or other electric or hydraulic drives up to 1 hp. **Airlectron, Inc.,** P. O. Box 151, Caldwell, N. J.

Circle No. **2** *on Reply Card*

TOOL RENEWAL

Tool control unit automatically shuts down machine when tools need changing. Instrument is suitable for all types of metalworking equipment including screw machines, drill presses, gear hobbers, punch presses, gear shavers, and

milling machines. Four models can be furnished with one, two, four, or eight Toolometers. Pointer on the Toolometer is set at a point representing the expected output of pieces per tool. It indexes counterclockwise with each machine cycle, and, upon reaching zero, automatically shuts down the machine. A red area on the instrument represents the danger zone or last useful period of tool life. When the control unit consists of more than one Toolometer, the operator combines all tool changes when machine stops for a specific change, and replaces all tools operating in the danger zone as indicated on other Toolometers. Combined tool changes reduce downtime and scrap loss, increase production, prevent machine overload, and establish standards of tool performance. **Dept. 44P, Cross Co.,** 3250 Bellevue, Detroit 7, Mich.

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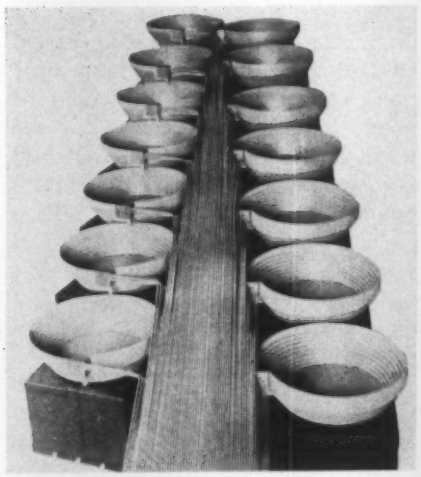

SMALL PARTS FEEDER

Battery of feeders can handle nearly half a million parts per hour by employing multi-track feeding principle. Operating flow from each track is 140 pieces per minute, and fourteen feeders are used in the illustrated installation. Feeders operate at same speed but independently of each other, and handle parts 3/16-in. in diameter and 1 in. long. Manufacturer designs and engineers special systems for small and fragile parts feeding processes. **Perry Equipment & Engineering Co.,** Brandes St., Erie, Pa.

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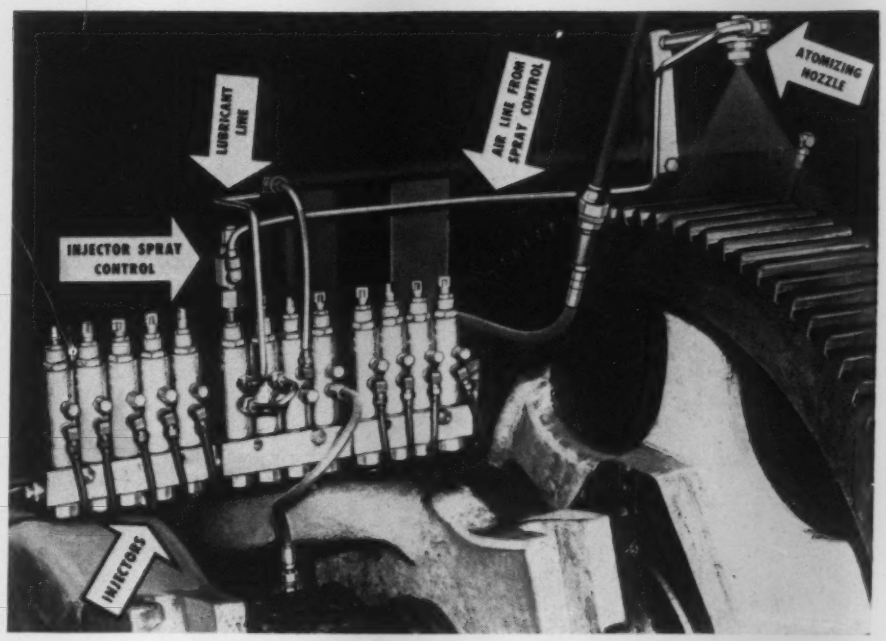


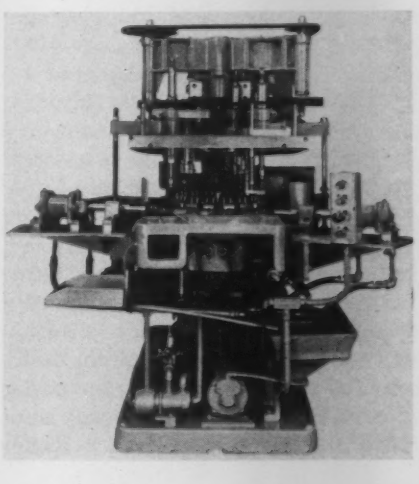
AUTOMATIC MIST LUBRICATOR FOR GEARS

Operating in conjunction with centralized lubrication systems, a new spray control valve automatically provides controlled mist lubrication for open gears. Unit is attached to any lubricant injector in the centralized system, and mounted either adjacent to or remote from the gears. As injector begins to discharge lubricant, movement of its indicator stem permits spray control valve to open. Valve allows regulated air to pass spray nozzle which atomizes lubricant into a fine, uniform mist of air and lubricant. Output can be increased by diverting lubricant from two or more injectors to the adjustable spray nozzle. **Lincoln Engineering Co., Industrial Div.,** 5794 Natural Bridge Ave., St. Louis, Mo.

Circle No. **5** *on Reply Card*

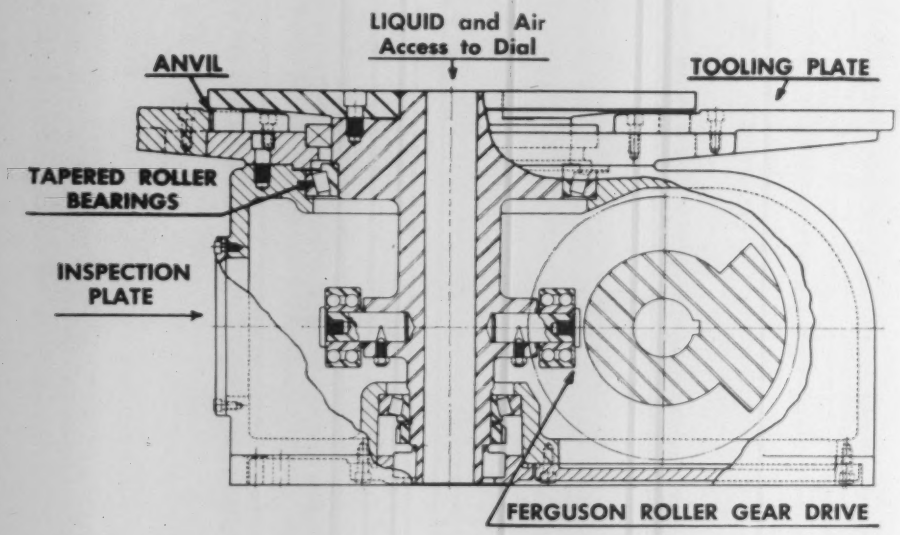
SHORT RUN PROCESSING MACHINE

Special tooling up of a standard automatic processing machine enables it to mass process three different parts having 22 variations in size and hole positions. All drilling, tapping, and milling operations are held to close tolerances. A horizontal and a vertical milling spindle have been incorporated to permit a light milling operation to be combined with drilling and tapping. Workpieces are needle valves in eleven different lengths, high speed nozzles in seven sizes with one to three metering holes at various locations and of different diameters, and float valve seats in four sizes with variation of seat ID. Needle valves are manually loaded, automatically clamped, drilled, countersunk, milled, tapped, and unclamped, and manually unloaded at the rate of 750 pieces per 50 minute hour. High speed nozzles are manually loaded, automatically positioned and clamped, drilled, milled, unclamped and ejected at the rate of 1500 pieces per 50 minute hour. Float valve seats are manually loaded, automatically clamped, reamed, rough and finish faced, milled, unclamped and ejected at the rate of 1100 per 50 minute hour. Tooling and spindle lay-



outs are designed for maximum interchangeability to facilitate rapid changeover from job to job. For instance, changeover from needle valve to nozzle job involves a complete change of dial and ring, yet takes only two hours. **Bodine Corp.**, 319 Mountain Grove Ave., Bridgeport, Conn.

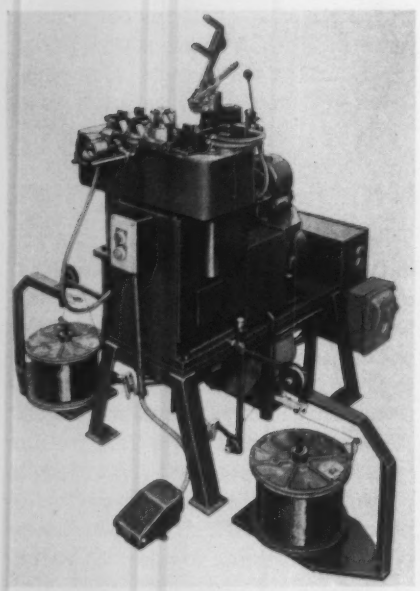
Circle No. 6 on Reply Card



FAST INDEX TABLE

Formerly available on a custom design basis, high speed index tables, known as Intermittors, are now marketed as standard units. Tables are furnished with 4, 6, 8, or 12 stops with dial sizes varying from 12 to 36 in. in diameter. Variations in movement time range from ¼ to ¾ of the total cycle. Table permits passage of coolant, or air or hydraulic fluid through the roller gear shaft and dial to the work area for actuation of product holding devices. Tooling may be attached to brackets which are provided outside the dial periphery. Used with company's roller gear drive as the indexing mechanism, Intermittor is said to attain speeds twice those of tables with other types of indexing devices while maintaining product quality. Self-locking feature and zero backlash permit smooth starting and stopping without auxiliary locking methods at speeds as high as 500 indexes per minute. Drive operates at least 8000 hours on close precision work, and 20,000 hours on less exacting jobs. Drive is renewed simply by replacing standard ball bearings. Precision is ±0.001-in. at the pitch diameter of the followers on the roller gear. Provision is made for shot pins on the larger dials. **Roller Gear Div., Ferguson Machine & Tool Co.**, P. O. Box 191, St. Louis 21, Mo.

Circle No. 7 on Reply Card



STATOR WINDING

An improved automatic stator winding machine is designed to wind 2, 4, 6, and 8-pole stators, all poles on any unit being wound simultaneously. Machine uses a single needle, indexes and reverses between poles, is adaptable to winding interconnected coils for series-wound stators. With multiple needles it can be wound for split-phase and multiple speed motors. Wire of 14 to 36 gage can be wound at speeds from 150 turns per minute with 14 gage to 600 turns per minute with 36 gage. Any number of turns from 1 to 2000 may be selected by automatic control, and selected cycle is automatically repetitive. Stacking heights up to 3-in. maximum and diameters up to 6-in. OD can be accommodated. An automatic winding-head positioner causes head to stop in same position at end of each cycle. Manual controls handle starting, emergency stopping, and finish lead pullout. The automatic lead cutoff serves as lead anchor in starting the next stator. Unit is powered by a standard 1 hp motor at 1140 rpm on 110/220 v, single-phase or 220/440 v, three-phase. **Fort Wayne Tool, Die & Engineering Co.**, Fort Wayne, Ind.

Circle No. 8 on Reply Card

LATHE SPEED CONTROL

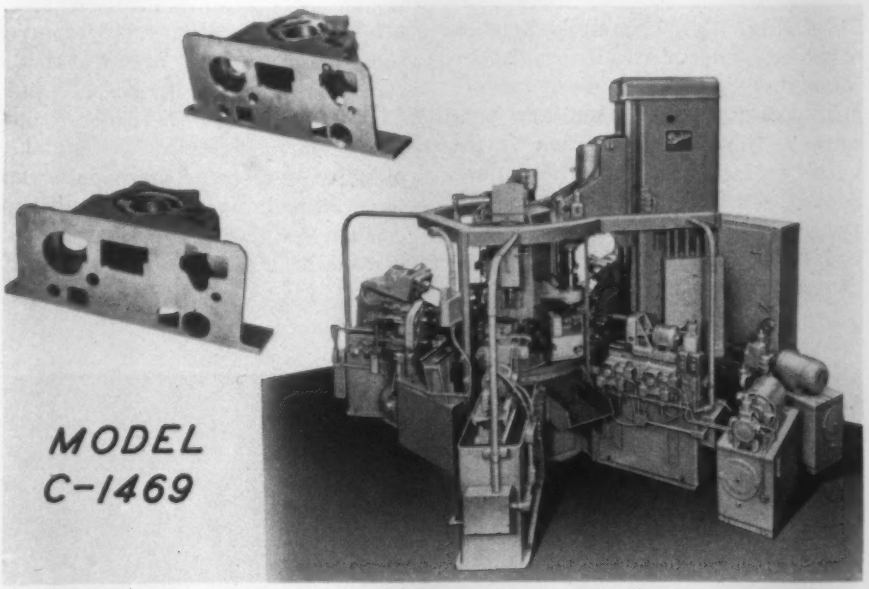
Powered by fractional and 1 hp dc motors, a new variable speed control requires no warmup time and will start readily under a heavy load. It is designed for use with lathes (as illustrated) and similar machines. Speed control effects time savings on jobs where several operations, requiring different speeds, are performed on the same piece of work. By its ability to quickly change speeds, control mechanism permits performance of facing operations while work continues without interruption. **Electro Products Laboratories, Inc.**, 4501 N. Ravenswood Ave., Chicago 40, Ill.

Circle No. 9 on Reply Card

AUTOMATIC PLOTTING BOARD

Electroplotter, an automatic plotting board, accepts inputs from punched cards, punched tape, and keyboard. Unit plots on a 30 x 30-in. surface with accuracy of one part in 1500 or 0.02 in. Roll paper can be used, and a vacuum paper hold-down system is provided. Numerical input of ± 9999 may be expanded to full scale or compressed to 1/3 full scale in both x and y axes. Input origin may be placed anywhere on the table. Electroplotter also features multiple spindle printing, serial keyboard, plug-in component construction, and light bank indication of numbers in the x and y registers. **Benson-Lehner Corp., Dept. A,9,** 2340 Sawtelle Blvd., W. Los Angeles 64, Calif.

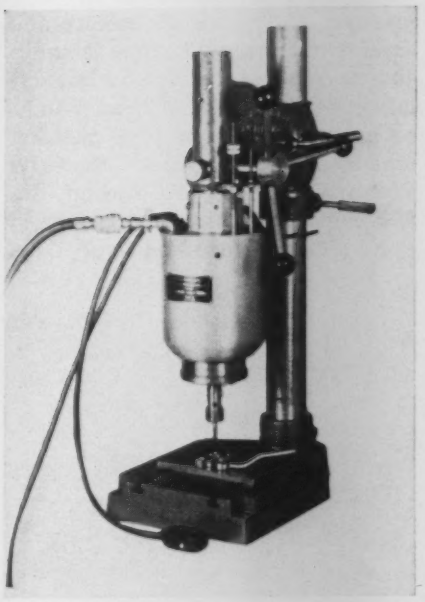
Circle No. **10** *on Reply Card*



MACHINE PROCESSES TRANSMISSION HOUSINGS

Designed to process transmission housings, an eight-way, six-station, center column, hydraulic feed, multiple spindle special processing machine drills, reams, counterbores, and face mills 90 pieces per hour at 100 per cent efficiency. Specially designed three-spindle power wrench with individual torque control actuates the fixture clamping mechanism. Machine also features a movable bushing plate and a 72-in. automatic index table which is equipped with a shot bolt which has a detachable indexing mechanism. All parts are interchangeable and are held to tolerances. All component assemblies are located by precision-bored dowels for alignment. Automatic lubrication and multiple heads of ball-bearing construction with shaved gears and broached-and-splined drives are incorporated. Automatic cam and roller type index is electrically controlled. **Buhr Machine Tool Co.,** Ann Arbor, Mich.

Circle No. **11** *on Reply Card*



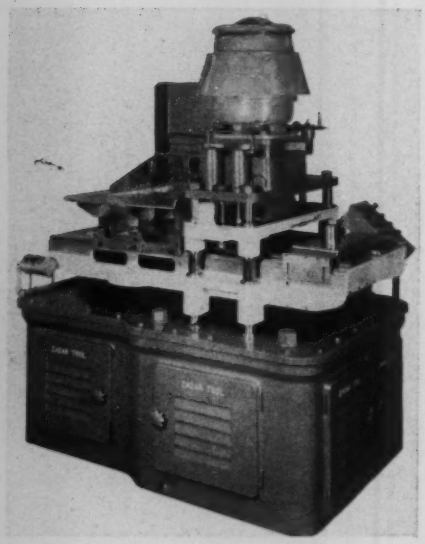
AUTOMATIC TAPPING

An automatic, electropneumatic tapping unit for high-speed, sensitive threading acts as its own automatic gage of tapping efficiency. Tap chuck is driven through a triple spiral spring mechanism which is sensitive to resistance to the cutting force. An air motor with electropneumatic control provides for momentary tap reversals at rates up to 200 cycles per minute. Any resistance, due to chip loading or in the material being tapped, instantly changes the rate of tap reverse-and-return as required for smooth operation. Any dull or improperly cutting tap will cause more than the usual frequency of reversal. If a tap is completely incapable of cutting further, the machine oscillates the chuck at the full 200-cycle rate of reversal without breakage. Observation of reversal rate thus gives check of tap con-

dition, coolant, and heat-treat variations.

Taps range in size from #2 x 56 to 5/16-in., and Class 3 threads are produced in a large range of materials. Cutting torque is controlled to the ounce. Hole depth can be preset to within ±0.0035-in., and machine works equally well in blind holes or through holes. Fully automatic cycle is carried through by pushbutton or footswitch, and total cycle time, exclusive of tapping time, is less than a half-second. Possible adjustments are in the permissible tap torque, the amount of rotative reversal, the depth of thread, and the lift-out force. Machine is available as a separate unit for mounting in other machinery, or mounted on bench or floor type pedestal stands of various sizes. **Smith & Weise Co.**, 1265 W. Second St., Cleveland 13, Ohio.

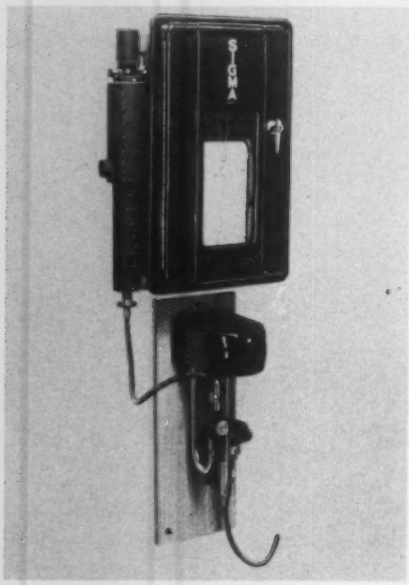
Circle No. **12** *on Reply Card*



DRILLING MACHINE

All movements on this high speed drilling machine are mechanical. Workpiece is loaded into a hopper manually and positioned under the drill head mechanically. As the next piece is fed into drilling position, it removes the finished piece. Machine drills holes 3/16-in. in diameter, and gearless type drill head permits centers as close as ¼-in. Drill head features 529 spindles, is driven directly by a 30-hp motor. Length of stroke, depth of drill, and rate of speed are adjustable to hole finish requirements. **Zagar Tool, Inc.**, 24000 Lakeland Blvd., Cleveland 23, Ohio.

Circle No. **13** *on Reply Card*



CALORIMETER

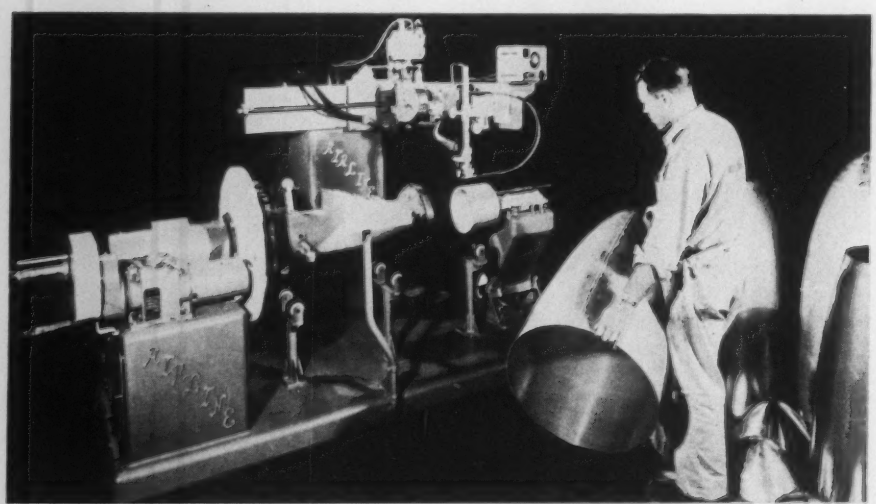
An English firm, Sigma Instrument Co., has modified its calorimeter to record directly and continuously in terms of heat flow factor instead of Btu by means of an alteration in the regulator. Originally, the regulator kept a constant flow of gas through the instrument despite changes in specific gravity. New regulator permits a flow of gas which is inversely proportional to the square root of the specific gravity. Therefore, heat available at the burner is proportional to the heat flow factor. This instrument eliminates spot checking of specific gravity and Btu value, the necessity for obtaining information by formula. Combined with any pneumatic control, calorimeter adjusts mixing of two gases and keeps heat flow factor constant. It can be equipped with electric alarm contacts to give visible or audible warning when heat flow factor goes over preset limits. Chart is 4 in. wide, driven ½ or 1 in. per hour, and powered by spring-wound or electrical clock mechanisms. **Cosa Corp.**, 405 Lexington Ave., New York 17, N. Y.

Circle No. **14** *on Reply Card*

AUTOMATIC EXPANDING

To solve problem of sizing, holding, and backing up joints for proper welding of round parts, manufacturer has incorporated end pressure and expanding mandrels into a new welding fixture to provide maximum alignment of abutting edges. This fully automatic circumferential expanding and welding fixture features fixture parts which unfold and swing out of the way so that operator is free to install parts to be welded. Welding head arm swings right 90° out of the way, and head or nose cone holder swings down for easy loading. One pushbutton on the control panel sequences all operations automatically while individual buttons start, stop, or reverse any operation. Machine is quickly changed over to accommodate various diameters or weld positions. **Airline Welding & Engineering**, 785 N. Prairie Ave., Hawthorne, Calif.

Circle No. **15** *on Reply Card*



AUTOMATION
THROUGH

VARITROL
CONTROL OF VARIABLE SPEEDS

WITH

U.S. VARIDRIVE
MOTORS

Varitrol pneumatic control gives automatic speed regulation of U. S. Varidrive motors for more efficient, more profitable production control. For more than 20 years the Varidrive has been recognized as the most compact and efficient device for obtaining variable speeds, with ratios up to 10:1 and capacity from ¼ - 50 HP. Many firms are increasing productivity with Varitrol control. Quality of product is improved, human effort is reduced.

US MOTORS

Varitrol is a new control device which regulates the speed of a Varidrive in response to a 3 to 15 psi signal, from such variables as Temperatures, Humidity, Pressure, Speed, Liquid Level, Weight, Tension, Position.

U. S. ELECTRICAL MOTORS Inc.
Los Angeles 54, Calif.
Milford, Conn.

REQUEST FOR VARITROL AND VARIDRIVE BULLETINS

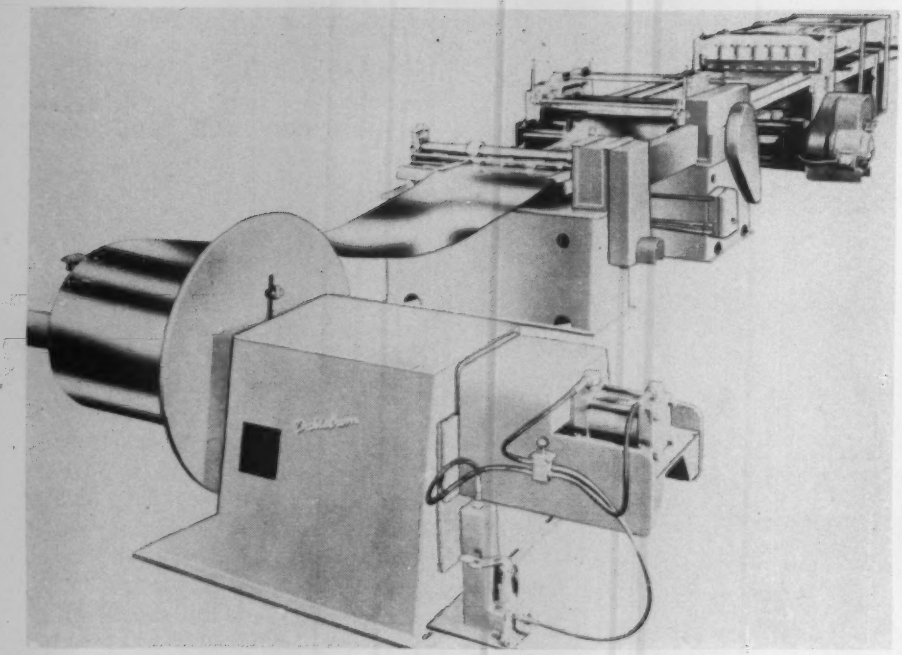
U. S. Electrical Motors Inc. A-12
Box 2058, Los Angeles 54, Calif. or Milford, Conn.

NAME_____

COMPANY_____

ADDRESS_____

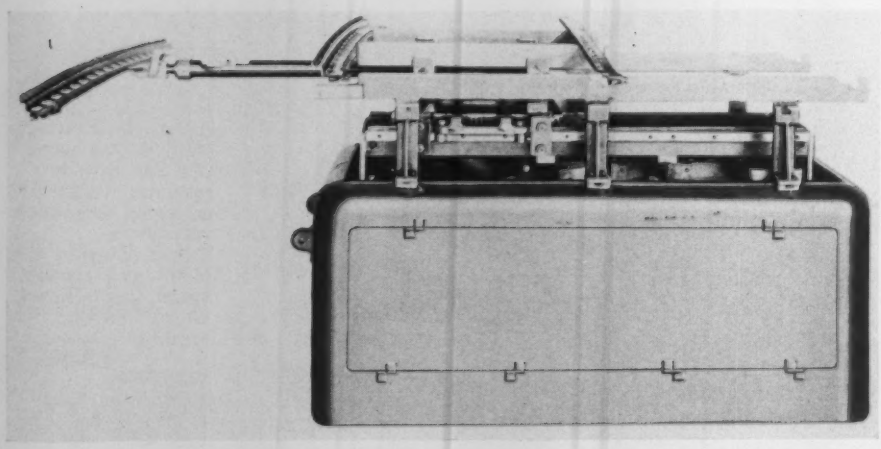
CITY ZONE STATE



DECOILING AND SHEARING LINE

A shearing unit permits use of coiled instead of flat sheet or strip, steel or aluminum, in production lines. Setup consists of the hydraulic expandable mandrel coil reel, a roll straightener with all rolls power driven, a hump table, a high speed shear, and a conveyor type measuring and take-off unit. Operations include decoiling, flattening, shearing, and measuring the metal. Steel or aluminum to be handled can be as heavy as 12-gage, and up to 72 in. wide. Speed of operation ranges from 50 to 150 fpm, and lengths are cut with tolerances of 1/32-in. Welded construction, antifriction bearings, ground shafts, and centralized control panel are featured. Equipment can be provided for edge trimming. **Dahlstrom Machine Works, Inc.,** 4227 W. Belmont Ave., Chicago 41, Ill.

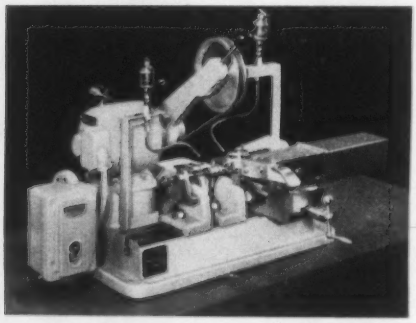
Circle No. **16** *on Reply Card*



AUTOMATIC LOADING

Automatic electric hands for use with presses and welding fixtures are ideal for small runs, are quick to change over to new parts. Used in the press room, machine automatically feeds parts into and withdraws them from press, keeping operator 5 to 6 ft from the press for safety. It will feed and withdraw parts automatically from a welding fixture, and act as index for a complete welding press line. As an index, machine moves parts for assembly at conveyor speed with a time dwell for assembly. In addition to four standard automatic hands, company can furnish special machines built to index any part that does not have to be rolled out of the die due to small opening of the press. **Hamilton Automation Inc.,** Hamilton, Ohio.

Circle No. **17** *on Reply Card*



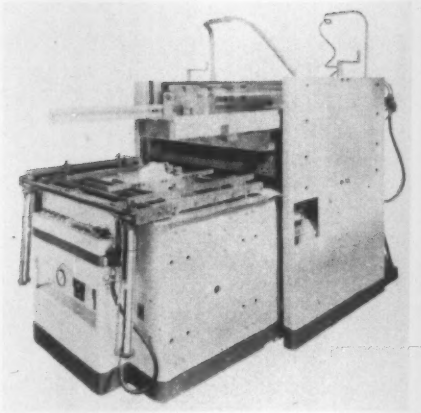
COMMUTATOR TURNING

Designed solely for armatures of small fractional horsepower motors, a new lathe turns the commutator while the armature revolves on its own axis. This new turning principle results in accuracy, fine finish, and increased production. Armature is mounted on two supports and rotated on its own shaft by the friction drive of a revolving belt. Commutator of the armature, rotating on a parallel axis, is turned to true concentricity. A power driven tool slide duplicates size on each piece automatically, and tolerances are held to 0.0005-in. on the duplicate work. Rotation at speeds up to 7000 rpm is suitable for diamond or carbide-tipped tools and assures a smooth finish. Two types of mounting are available whereby shaft of the armature revolves either on two carbide inserted vee blocks or on the periphery of two ball bearings. The vee block mounting is recommended for shafts $\frac{1}{4}$-in. or smaller in diameter. **Rivett Lathe & Grinder, Inc.,** Brighton 35, Boston, Mass.

Circle No. **18** *on Reply Card*

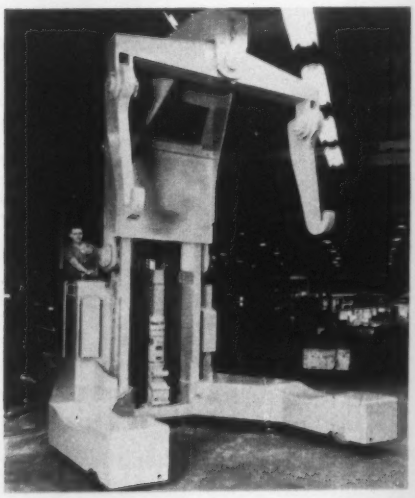
PLASTIC FORMER

All important controls are grouped together directly under operator's hands for manual or automatic control of a new thermoplastic drape and vacuum forming machine. Smallest standard model has sheet size capacity of



26 x 38 in., and largest has 54 x 78-in. capacity. Adjustable clamping mechanism has synchronized twin toggle action for perfect alignment. Travel is adjustable from ¼ to 12 in. in 1-in. increments, and speed of travel can be regulated to suit any material being vacuum formed. Temperature is controlled by a Wheelco Capacitrol unit and a thermocouple with provision for extra heat at the front and end sections. Electrical consumption is 8 w per sq in. Machine is ideally applied to parts manufacture in the refrigeration, packaging, aircraft, and automotive industries. **Auto-Vac Co.**, 2116 Post Rd., Fairfield, Conn.

Circle No. **19** *on Reply Card*



MOLTEN METAL HANDLER

High lift, crucible handling electric straddle truck was designed to transport ladles of molten aluminum from furnace to pouring station. Capacity is 20,000 lb. Overall height of machine is 154 in., with maximum lifting hook height of 103 in. Power for drive and

faster! more channels!
more versatile!

THE NEW POTTER DIGITAL MAGNETIC-TAPE HANDLER

0 to 60 inches/sec. in 5 msec! 2, 6 or 8 channels

High-speed magnetic tape recorders with low start-stop times bring a new dimension to data handling by absorbing and dispensing digital information **when and where it's needed!** Any phenomenon can be recorded **as it occurs,** continuously or intermittently, fast or slow. It can later be fed into computers, punch cards, printers, etc.

Speeds of 60 inches per second with 5-millisecond start-stop times permit digital techniques with jobs previously requiring more expensive, less reliable methods. Typical applications include business problems, high-speed industrial control processes, missile study, and telemetering.

In addition, Potter Magnetic Tape Handlers offer wider tape widths for more channels with lower tape tension controlled by photoelectric servos. Yet, the price is a fraction of much less versatile recorders. Other data handling components and complete systems are available for special problems.

DETAILED SPECIFICATIONS

Model	902AJ	902BJ	902BK	902CJ	902CK
Number of Channels	2	6	6	8	8
Tape Width (inches)	¼	½	½	⅝	⅝
Tape Speed (in./sec.)	15/30	15/30	15/60	15/30	15/60
Reel Size (dia. in inches)	10½	10½	8	10½	8
Reel Capacity (feet)	2,400	2,400	1,200	2,400	1,200
Start Time	5 Milliseconds				
Stop Time	5 Milliseconds				

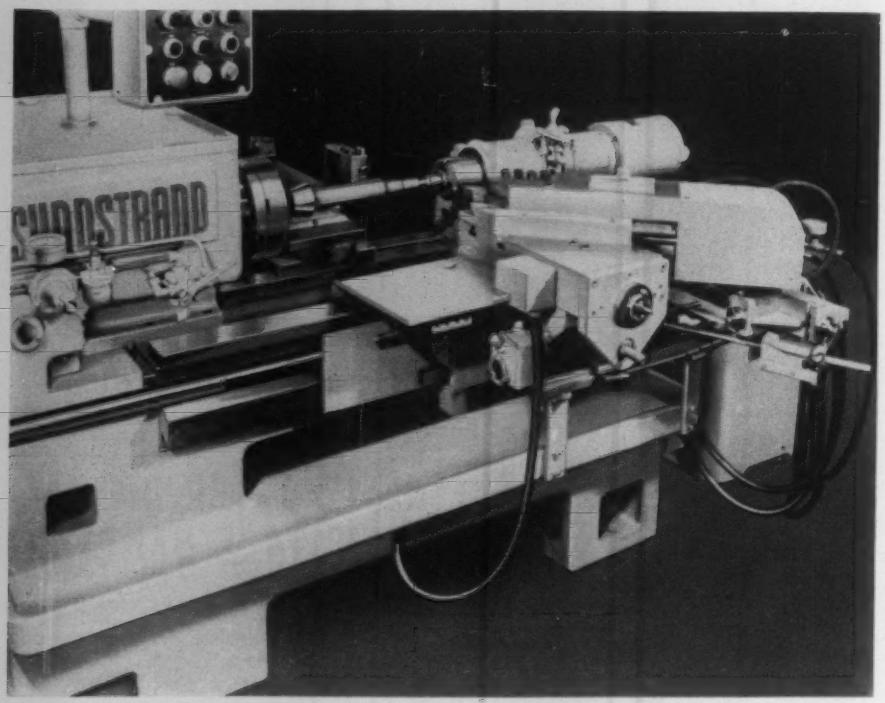
For complete information, write to Department 10-F.

Potter

POTTER INSTRUMENT CO., INC.
115 Cutter Mill Road, Great Neck, N. Y.

hoist operations is provided by a diesel electric unit. Unusual feature is dual control setup for right or left hand operation, insuring maximum operator visibility. **Yale & Towne Mfg. Co.,** 11000 Roosevelt Blvd., Philadelphia 15, Pa.

Circle No. **20** *on Reply Card*



AUTOMATIC LATHE TRACER CONTROL

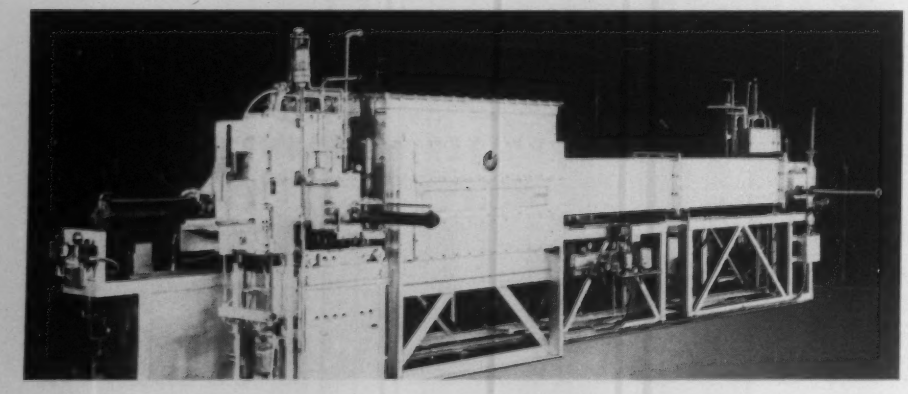
A template controlled tracing slide can be mounted to the regular front carriage of company's automatic lathes to provide multi-cycle single point turning of irregular shapes. Attachment roughs, semi-finishes, and finish cuts with one turning tool in one automatic cycle, and only one template is required for all three cuts. One, two, or three cycles can be set up on machine, and cycle changeover takes only 5 to 15 minutes depending on number of facing tools to set up. The regular cross feeding rear slide squares up shoulders and chamfers. **Sundstrand Machine Tool Co.,** 2531 Eleventh St., Rockford, Ill.

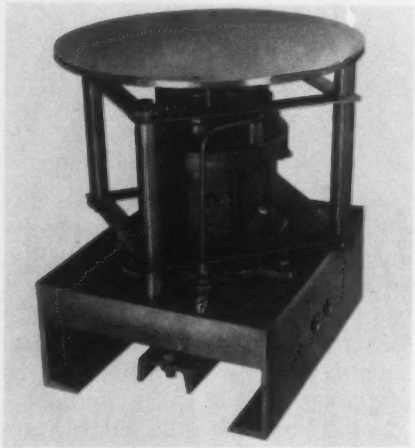
Circle No. **21** *on Reply Card*

AUTOMATIC PUSHER BRAZING FURNACE

Sequence of operations is automatically timed and synchronized for continuous production with one operator in a new pusher type furnace. Machine continuously bright brazes stainless steel with copper or stainless steel brazing compound at temperatures up to 2150° F. It will maintain dry hydrogen atmosphere and uniform heat distribution. Engineered for integration into production lines, furnace can reduce materials handling costs to a minimum. **Harper Electric Furnace Corp.,** 39 River St., Buffalo 2, N. Y.

Circle No. **22** *on Reply Card*





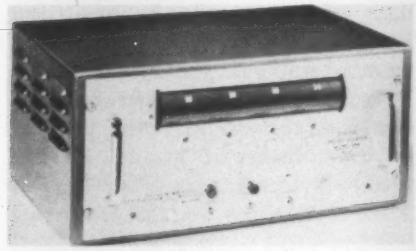
PLATFORM WEIGH SCALE

Electric platform scale utilizes strain gage load cells and pneumatic tare weight to procure net weight measurement. Scale is adaptable to either batch weighing or continuous process control. Structure's design employs flexural pivots to eliminate undesirable effects of off-center loading and to obtain special high and low weight measurements. Pulsation dampers can be supplied for vibrating loads. Typical applications of the platform scale include check weighing, tank weight inventory, solids batching, and incorporation as a constant weight belt feeder. **Weighing Components, Inc.,** 64 Fulmor Rd., Hatboro, Pa.

Circle No. **23** *on Reply Card*

ELECTRONIC COUNTER

A digital preset counter can be set to deliver an output pulse or to actuate relay contacts at the end of a predetermined count for automatic control of the number of units being fed into a package, or to control speed, frequency, or a similar variable. Counters can be preset at any number from 0 to 9999 and can be made to recycle at repetition rates as high as 30 kc. Use of presetting switches does not affect counting speed and unit can operate as a straight electronic



counter at speeds up to 100 kc. Unit will operate at high recycling speeds with a voltage output, or at low recycling speeds, or on single cycle with relay contacts for output. Direct coupling is used for the electronic output. Change in dc level on single-cycle operation will remain at the new level until the unit is reset. Used with a precision pulse generator, preset counter becomes a precise time interval generator. Square waves or single period intervals can be obtained. Input circuit accepts a variety of impulses including sine waves or rectangular pulses with peak amplitudes of at least 1 v. Circuit operates from 0 to 100 kc. Dual set of preset switches can be used to provide upper and lower limit control. **Brush Electronics Co.**, 3405 Perkins Ave., Cleveland 14, Ohio.

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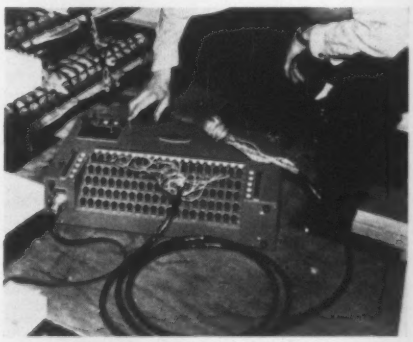


CABLE INSPECTOR

An automatic electrical wiring inspection system consists of a master and a slave unit for continuous circuitry scanning. Conductors are scanned at the rate of one per second, and insulation resistances up to 110 megohms at 350 v dc are checked. Higher resistance limits and test voltages can be supplied. Unit also locates direct shorts by means of a sensitive electronic leakage detector, and automatically "rings-out" multiple circuits. It automatically

Digital Computer Techniques

Applied to the design, development and application of

Electronic Business Systems
Military Radar Fire Control Systems
Aircraft Control and Navigation Systems

The successful application of Hughes airborne digital computers to high speed aircraft fire control problems has opened up an entire new area for these digital computer techniques. Similar equipment is now under development in the Advanced Electronics Laboratory to apply such digital computer systems to modern business information handling.

Areas include

LOGICAL DESIGN
COMPONENT DEVELOPMENT
PROGRAMMING
MAGNETIC RECORDING
CIRCUIT DESIGN
INPUT & OUTPUT DEVICES
SYSTEMS ANALYSIS

Hughes *developments in these fields are creating new positions in the Advanced Electronics Laboratory. Exceptional men in the following spheres of endeavor are invited to apply:*

Engineers and Physicists

Computer activities embrace systems planning and analysis, design and development, system engineering and component development. Experience in these areas, as well as in application of electronic digital computers, is desirable but not essential. Analytically inclined men with backgrounds in systems work are required for this phase.

Scientific and Engineering Staff

Hughes

RESEARCH AND DEVELOPMENT LABORATORIES

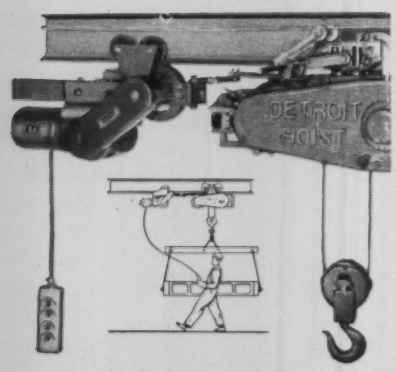
Culver City, Los Angeles County, California

Assurance is required that relocation of the applicant will not cause disruption of an urgent military project.

identifies individual wires in multiconductor cables, conduits, wireways, and terminal boxes. Typical applications include original testing and maintenance of control cables, transmission lines, instrument and control panels, feeder and branch circuits, thermocouple leads, and communication lines. Adaptors can be provided to match any plug-in connector, and fanning strips are used to check conductors wired to terminal blocks. Cable faults are detected by dc bridge circuits using vacuum tubes and relays as sensing devices.

Master unit consists of operating controls and adjustments, is used for all inspection functions. Slave unit is used only for identification of cable circuits. For "circuit seeking," master and slave units can be separated by as much as five miles, with only one connection, other than the cable being identified, between the two. Connection can be plant or actual ground. Slave unit can be used alone for conductor identification on construction projects where individual conductors or small groups of conductors are run from widely scattered locations to a central terminal point. Interconductor and ground insulation resistance tests utilize master unit alone. **Panascan,** 7499 N. Hamlin Ave., Skokie, Ill.

Circle No. **25** *on Reply Card*



POWER TRACTOR

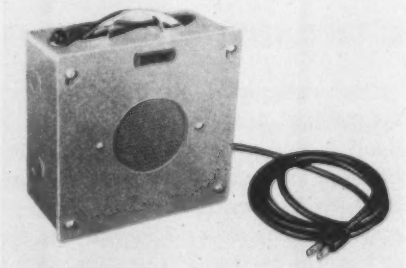
Tractor attaches to practically any existing hoist, light overhead crane, or other hand traveled equipment and quickly converts it into an electric power traveled unit by means of a simple draw-bar. Unit is available in six sizes to handle loads from ½ to 10 tons at speeds ranging from 30 to 90 fpm. Steel frame is carried on four steel wheels with hardened tread and ball bearings, and 8-in. diameter steel wheel has neoprene solid tire tread. Reduction gearing combines spur and worm gearing connected through the roller chain and sprocket to the driving wheel. Medium torque, slow starting, intermittent duty type motor is ½ or 1 hp. Pushbutton control station is suspended on a heavy duty conductor from the tractor. Tracks may be furnished for any standard regular or wide flange I-beam, and for monorail tramrail tracks. **Detroit Hoist & Machine Co.,** 8220 Morrow St., Detroit 11, Mich.

Circle No. **26** *on Reply Card*

LOADER FOR GEAR SHAVING MACHINE

An air powered, semiautomatic loading device increases production rates of standard rotary gear shaving machines by cutting operator's seven ordinary manual loading and unloading functions to three. Machine provides tailstock and splash door air cylinder controls, electrical controls, and a special work locator suitable for the particular gears whose teeth are to be finished. In addition, the loader acts as a safety device because operator's hands are kept out of the cutting area during the shaving operation. Operator merely places the gear in mesh with the cutter, resting the gear on the approximate locator, presses the cyclic start button, and removes gear upon completion of cycle. After the work has been positioned and the starting button pressed, the splash guard door cylinder closes the door, the tailstock air cylinder advances the tailstock, the coolant is turned on, and the cutter starts to rotate in mesh with the gear. **National Broach & Machine Co.,** 5600 St. Jean Ave., Detroit 13, Mich.

Circle No. **27** *on Reply Card*

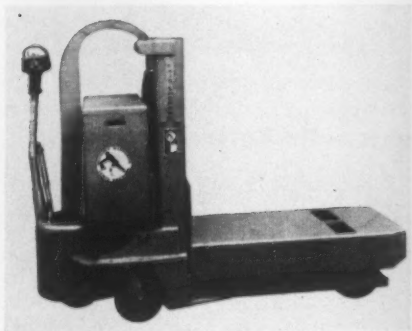


PERSONNEL PAGING

Portable paging unit of a personnel paging system can be plugged into any ac power outlet within a building to receive coded

signals without special wiring. Audible and visible signals are received regardless of noise level or distance from stationary signals. System utilizes identifying code numbers assigned to personnel. A code-selecting plug is inserted into the central code selector and superimposes high-frequency signaling pulses on regular ac wiring to sound signals throughout the building. Special signals may then be sounded to indicate paging reason, such as "telephone call" or "customer waiting". System can be used to page watchman with pushbutton mounted at main entrance to sound signals throughout the building and actuate his portable unit. Automatic work and rest period signals and emergency alarms can be programmed. **International Business Machines Corp.,** 590 Madison Ave., New York 22, N. Y.

Circle No. **28** *on Reply Card*



LOW-LIFT TRUCK

"Walkie" electric truck features low lift and heavy capacity up to 16,000 lb. Truck has articulated frame which permits use of stabilizing casters on the load-carrying frame. Driving portion of truck and battery are hinged to the load-carrying frame by a parallel linkage so that weight of the load is distributed over the four rear wheels and two casters instead of on the drive wheel. Four-in. electrohydraulic lift and lowering action are controlled from the handle head. Electric brake can be released while control handle is in vertical position to save aisle space. Truck is capable of right-angle turning in 89-in. wide aisles. Platform is 48 x 25 in., while overall truck length is 84 in. **Dept. R-61, Lewis-Shepard Products, Inc.,** Watertown, Mass.

Circle No. **29** *on Reply Card*

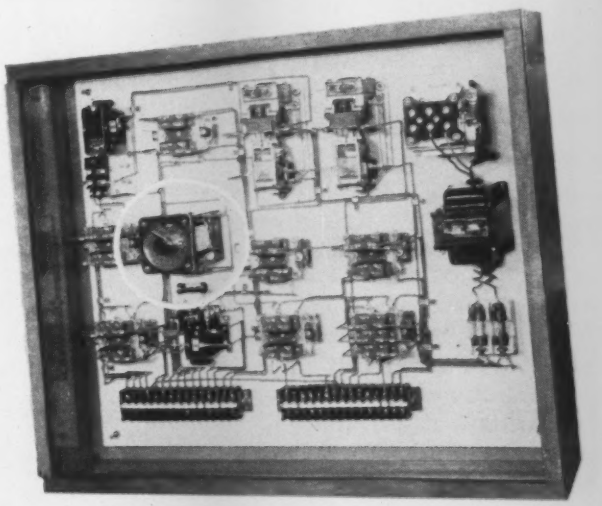
Automation

STARTS WITH

EAGLE Timers

FOR ANY SIZE INDUSTRY

WELDING



The Eagle Cycl-flex Reset Timer meets the specific requirement needed for more flexible control of the Peck Automatic Welder. The Cycl-flex with its flexible time and electrical control features made it the ideal timer for regulating the proper "overlap" and "arc cutoff" phases of the cycle. The timer is easy to set — easy to read — it has cycle progress indication.

Eagle builds timers for controlling hundreds of processing applications. Let Eagle engineers go to work for you.

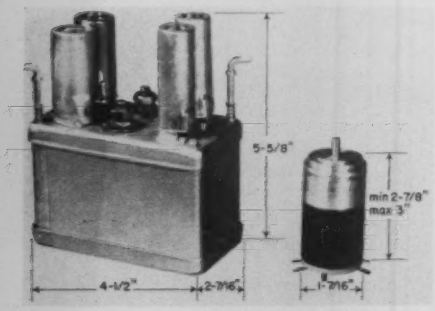
Send for FREE Automation Booklet "See what timing can do for you?"

Industrial Timers by EAGLE

EAGLE SIGNAL CORPORATION MOLINE, ILL.

AUTOMATION NEW COMPONENTS

Parts, elements and devices designed for creating more automatic systems



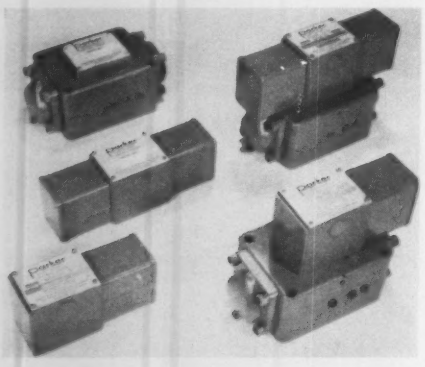
Packaged Servo System

A complete packaged servo system includes amplifier, motor, and gear train. Screw driver adjustments are featured in the amplifier to meet a wide variety of load conditions. Carrier frequency may be 60 plus or minus 2 cycles per second, or 400 plus or minus 4 cycles per second, depending on model. Power output is 1.5 w and input impedance is 1 megohm. Typical damped natural frequency is 12 cycles per second in the 60 cycle model, and 40 in the 400 cycle model. System can be applied to synchro data transmission systems, laboratory and industrial instrumentation, computers, fire control equipment, and automatic systems. **Feedback Controls Inc.,** 1332-34 N. Henry St., Alexandria, Va.

Circle No. **30** *on Reply Card*

Directional Control Valves

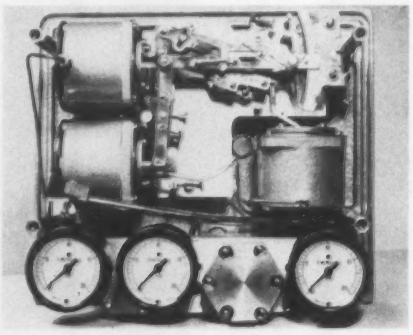
A series of five new directional control valves has been added to company's line of hydraulic units. New models are designed for hydraulic oil systems with operating pressures up to 2000 psi. All are supplied for gasket type mounting, but subplates are available if required. Five models are: pilot operated, solenoid operated (single or double), and solenoid controlled-pilot operated (single or double solenoid). Solenoid valves are rated at a recommended maximum capacity of 3 gpm. Two subplates can be furnished, one for flows up to 1 gpm with $\frac{1}{4}$-in. pipe threads, and the other for flows up to 3 gpm with $\frac{3}{8}$-in. pipe threads. Pilot operated and solenoid controlled-pilot operated valves are rated for maximum capacity of 22 gpm, and subplate is tapped for $\frac{3}{4}$-in. pipe. Pilot pressure may be 50 to 2000 psi.



Normally arranged for internal pilot pressure source, pilot operated valves can be furnished for use with an external pilot pressure source.

One to six spools are offered in each design, and all spool types are interchangeable in the same body. Spools may be spring centered, spring offset, or two position-no spring. A special tandem spool is available for the 3 gpm valve. Solenoids are usually furnished for 115 v, 50 or 60 cycle ac, but can be supplied for specified voltages and frequencies. **Parker Appliance Co.,** 17325 Euclid Ave., Cleveland 12, Ohio.

Circle No. **31** *on Reply Card*



Automatic Ratio Relay

Pneumatic relay multiplies two different input pressures to provide a proportional outgoing pressure. Primary applications for this Tel-O-Set automatic ratio relay are in the metal processing, petroleum, and chemical industries. Relay receives two pressure signals, from 3 to 15 psi each, and transmits an output pressure which is proportional to the primary input pressure. Ratio between output and input is adjusted by the second input pressure. Maximum range of ratios is 0 to 2, corresponding to the 3 to 15 psi change in ratio setting pressure, but ratio span may be changed to any desired value within this range by means of internal adjustment screws. Assembly includes limit stops on the output pressure, suppression adjustments for all pressures, adjustable pulsation dampers on both input pressures, and a high-capacity, non-bleed pilot valve for large loads. Separate gages indicate input and output pressures. **Minneapolis-Honeywell Regulator Co., Industrial Div.,** Wayne & Windrim Aves., Philadelphia 44, Pa.

Circle No. **32** *on Reply Card*

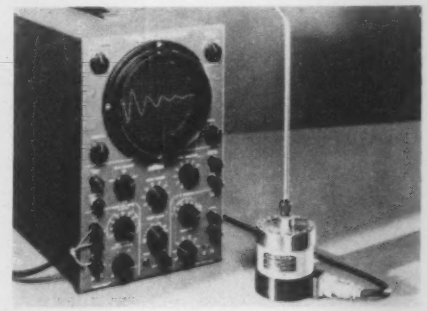
Two-Circuit Timer Control

A new repeat cycle dial timer, the "Duo-Set", controls on-off cycling of two independently adjusted load circuits in machine and process control. Timer is available in 9 dial ranges from 30 seconds to 4 hours, with minimum settings as low as ½ second. Synchronous motor drives elapsed time indicator up scale and down scale to setting pointers. Reversal is smooth and self-synchronizing, without springs or other mechanical assemblies. For motor drive reversing applications delay can be set up between deenergizing of forward and energizing of reverse, and delay can be as much as 40 per cent of dial range. Two operations can be set on the dial range with no "cross-over" setting hands to limit time settings. A manual override button on the front plate permits quick stopping or resetting of indicator during cycle without interrupting motor or straining any part of the mechanism. No additional external switches are necessary. Timer is applicable to control of electrically heated equipment, conveyor drives, solenoid valves, and pumps. **Automatic Temperature Control Co. Inc.,** 5212 Pulaski Ave., Philadelphia 44, Pa.

Circle No. **33** *on Reply Card*

Pressure Transmitter

Pressure information is relayed from a remote or hazardous location to a central control room several thousand feet distant by a new Teledyne bonded strain gage pressure transmitter. Combined with suitable self-balancing potentiometer type recorders, controllers, and valve systems, instrument controls pressure of chemical and similar processes accurately. Recorder can be equipped with electrical contacts for actuating alarms indicating approach to or deviation from desired pressure limits. Teledyne consists of a stainless steel, corrosion resistant pressure chamber which can withstand even strong, hot acids. It gives maximum response to dynamic pressures such as vibration, pulsation, and surges resulting from piston or rotary pumps, or opening and closing of valves. Pressure is asserted on a thin stainless steel diaphragm which actuates a lightweight piston in contact with the electrical sensing element. This element consists of a precision metal ring acting as

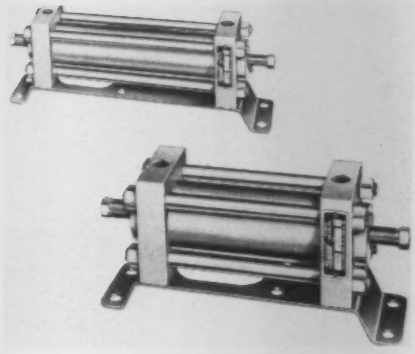


the elastic member to which four electrical resistance strain gages are bonded in a bridged circuit. Two are bonded to internal surface of the ring and are in compression when ring is flexed. The other two are bonded to ring's external surface and are in tension. Electrical unbalance is proportional to increase of pressure. Instrument's high frequency response suits it to testing of rocket, pulse jet, turbo jet transmission pipe lines, and hydraulic systems. **Taber Instrument Corp.,** Section 78, 111 N. Goundry St., N. Tonawanda, N. Y.

Circle No. **34** *on Reply Card*

Lubricant Measuring Valve

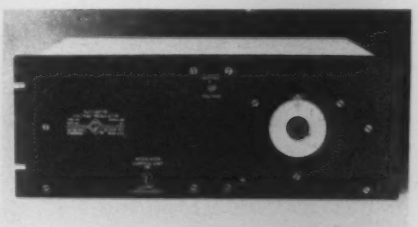
Predetermined, measured quantities of lubricant are dispensed at any discharge output rate desired by a line of hydraulically operated valves. An adjusting screw at each end of the measuring chamber controls the quantity of lubricant output. Units are designed for use with a four-way control valve which is supplied with lubricant from a power-operated pump. This system will automatically apply oil or grease to gear cases, small transmissions, bearings, and electric motors in assembly line operations. **Lincoln Engineering Co., Industrial Div.,** 5794 Natural Bridge Ave., St. Louis 20, Mo.



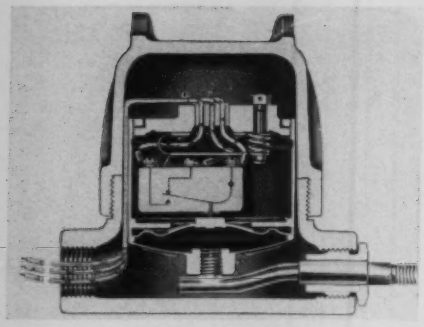
Circle No. **35** *on Reply Card*

Line Voltage Regulator

Automatic voltage regulator is composed of a Variac ® autotransformer which adjusts output voltage, a buck-or-boost step-down transformer which multiplies the Variac's power rating, and a servomechanism that positions the Variac. Proportional control servomechanism is said to have better accuracy and transient response than the on-off type of control circuit. Regulator has 6 kva capacity, 0.25 per cent accuracy, and no power-factor restrictions or waveform distortion. Output voltage is adjustable over a range of ±10 per cent from a base value of 115 or 230 v, is maintained if input voltage does not vary by more than ±10 per cent from the set value of the output voltage. Response time varies from 10 v per second to 40 v per second depending on output voltage and variation range. Three models are a metal cabinet for bench use, a metal cabinet with relay rack fittings, and a metal box for wall or switchboard mountings. Regulator is adaptable to electrical, electronic, and photographic laboratories. **General Radio Co.,** 275 Massachusetts Ave., Cambridge 39, Mass.



Circle No. **36** *on Reply Card*



Pressure, Vacuum Switch

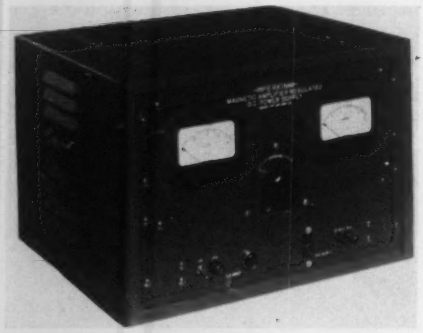
Compact pressure and vacuum switch repeats within ±1 per cent of setting. Explosion-proof housing permits use in atmospheres containing vapors of ethyl, ether, gasoline, alcohol, acetone, petroleum, naphtha, and lacquer solvents, as well as natural gas and grain dust. Instrument covers range from 30 in. of mercury proof vacuum to 150 psi, sensing increasing or decreasing vacuum or pressure. Single or dual settings are available. With dual setting, two different pressure limits are secured and two electrically independent circuits are actuated. One circuit may be ac and the other dc if desired. Switch is automatically reset by snap action. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle No. **37** *on Reply Card*

Continuous Business Form

A new continuous form has been designed for high speed equipment such as addressing, tabulating, billing, and accounting machines, teletypewriters, detachers, decollators, and similar forms handling equipment. Design of form assures its positive register, accurate sheet-length control, and faster feeding. Intermediate handlings do not effect the form's alignment. Narrow carbon is used, and special interlocking perforations which anchor all parts, including the carbons, in place. This permits forms to be run at high speed, then folded and refolded without disturbing their register. **Moore Business Forms, Inc.,** 900 Buffalo Ave., Niagara Falls, N. Y.

Circle No. **38** *on Reply Card*



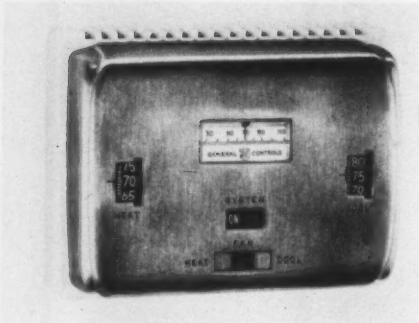
Magnetic Amplifier DC Supply

Selenium rectifier stacks and magnetic amplifier regulation circuitry, with no moving parts or contact, are utilized in a new tubeless regulated dc power supply. Illustrated model is rated at 5 to 32 v at 15 amp with 1 per cent regulation over entire dc output voltage range and 1 per cent ripple. Response time is 0.2 second. Units in this series are also stabilized for 105-125 v ac 230/460 v ± 10 per cent. **Perkin Engineering Corp.,** 345 Kansas St., El Segundo, Calif.

Circle No. **39** *on Reply Card*

2-Dial Master Thermostat

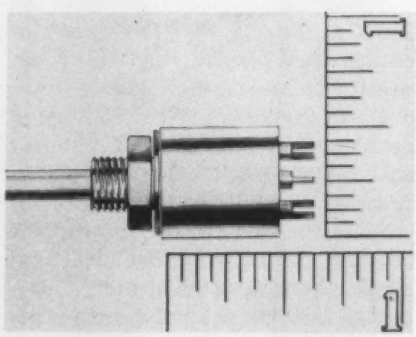
Summer-winter air conditioning systems are controlled from a single point by a new, easily operated two-dial master thermostat. Unit is designed for use with a mv heating circuit and a 24-v cooling system circuit, and has independent fan control for ventilation purposes. Easy readability is featured in the bi-metal window view thermometer and the two temperature selection dials for heating and cooling. A master control of both furnace and refrigeration units has a single sliding switch that gives operator a choice of heat, fan, or cool. The two selection dials are independent of one another to avoid the need for frequent reselection of temperatures when conditions require alternate operation of both systems. In "fan" position, the blower is turned on for air circulation without temperature control. In "cool" position, the blower continues to operate and temperature level is maintained at the setting on the "cool" dial. Response to temperature change is excellent. **General Controls Co.,** 801 Allen Ave., Glendale, Calif.



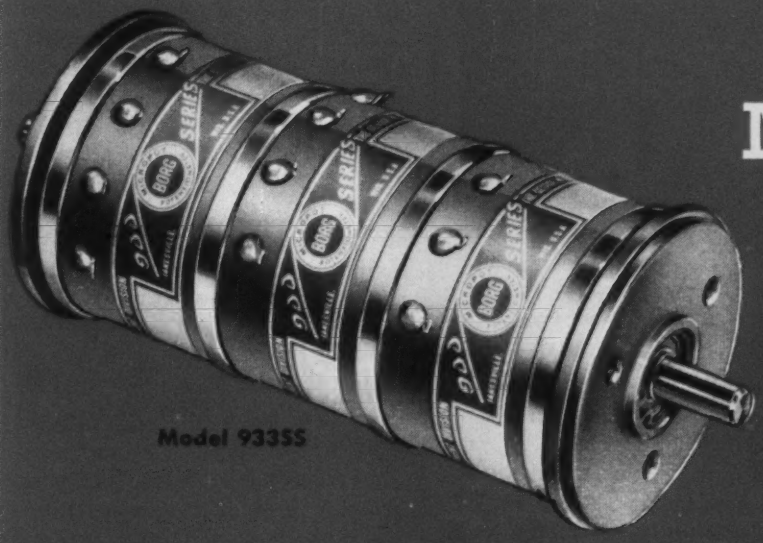
Circle No. **40** *on Reply Card*

Wire Wound Potentiometer

Acepot, a subminiature potentiometer, features standard linearity of ± 0.3 per cent, with closer tolerances available on special order. Only ½-in. in diameter, instrument has low dielectric constant and power factor and extremely low torque. It is available with threaded bushing, servo, or tapped hole mountings. Resistance range is 200 to 50,000 ohms with ± 2 per cent tolerance, and ambient temperature range is − 55 to 125 C. The resistance element is wire wound on a symmetrically shaped flat phenolic card finished by special process seating wires in permanent position. Specially coated copper strip card can be substituted for higher power loading on special order. Bearings can be Oilite bronze, sapphire jewel, or miniature precision ball type, and termi-



BORG MICROPOTS



Model 933SS

the NEW STANDARD of precision multi-turn potentiometers

BORG 900 SERIES 3-TURN AND 10-TURN MICROPOTS

3-TURN MODELS 931-935 | **10-TURN MODELS 901-903**

Standard models of Borg 900 Series Micropots offer such flexibility that they meet special design needs. Borg has created a new standard for high-precision, multi-turn potentiometers.

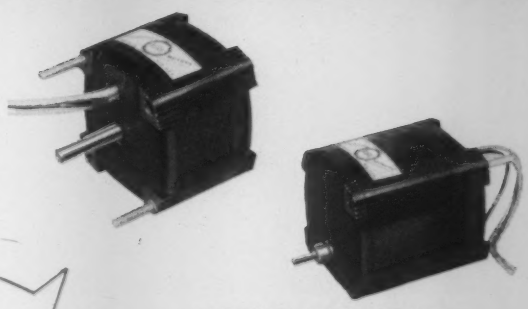
Advantages of the Borg 900 Series include greater accuracy, finer resolution, lower torque, longer life, better performance under severe and excessive vibration, greater adaptability and versatility of application.

Standard models include: 10-turn precision Micropots in 1 to 5 gang models, 3-turn in 1 to 5 gang models, single or double shafts, servo or bushing mounts on either or both ends. Available to designers and engineers in any quantity.

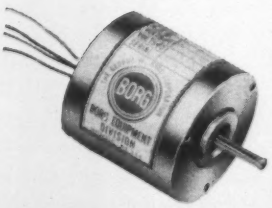
SYNCHRONOUS AND INDUCTION BORG-MOTORS

1000 SERIES 2 POLE AND 4 POLE MODELS
With and Without Gear Trains

These Borg-Motors were designed specifically for instrumentation, control and timing devices. They are recommended for all applications where low torque, constant speed and long life are positive requirements.



For Complete Engineering Data



SERVO-CONTROL
Borg-Motors

Two phase, 115 volt, 400 cps induction type Borg-Motors for servo control applications. Approximate size 1½" diameter x 2" long with a locked rotor torque of 0.82 ounce-inch.

ATTACH TO YOUR LETTERHEAD

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

NAME.....

TITLE.....

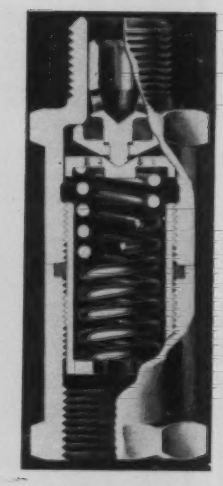
Please send complete information and engineering data on items checked.

- ☐ Precision Multi-Turn Potentiometers, 900 Series
- ☐ Borg Standard Potentiometer, 1100 Series
- ☐ Precision Multi-Turn Counting Dials
- ☐ Servo Control Motors
- ☐ Frequency Standards
- ☐ Instrument Motors
- ☐ Contract Manufacturing

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

nals can be gold or silver plated solder, or wire lead. Standard shaft is 0.125-in. diameter centerless ground stainless steel, with slotted or special shafts available. Potentiometers are sealed against sand, dust, etc., and all materials used have been treated for resistance to corrosion, humidity, and salt spray. **Ace Electronics Associates, Potentiometer Div.,** 125-129 Rogers Ave., Somerville 44, Mass.

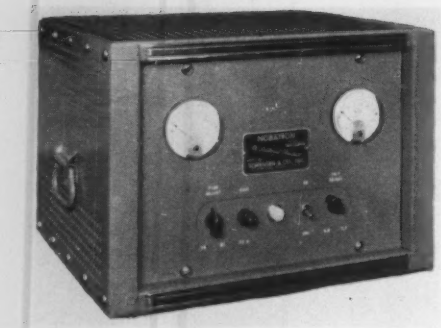
Circle No. **41** *on Reply Card*



Relief Valve

Valve for almost any gas or liquid application is lightweight and easily mounted. Cracking pressure can be adjusted within ±15 per cent of nominal with a socket wrench rotating the threaded spring retainer. Wider range of adjustment is provided when interchangeable replacement springs are used. Performance curve shows small, steady increase in pressure drop as flow rate increases, assuring stable action and chatter-free operation. O-Ring seal and spring centering permit axial force only to be transmitted to the poppet for durable but sensitive valve operation. No leakage is reported within as little as 2 per cent of preset cracking pressure, or 5 per cent of the setting when valve reseats. Brass or steel models are available for pressures from 50 to 1000 psi, and a stainless steel model with Teflon seal can be supplied in ¼, ½, ⅜, and 1 in. sizes. **Circle Seal Precision Valves, James-Pond-Clark,** 2181 E. Foothill Blvd., Pasadena 8, Calif.

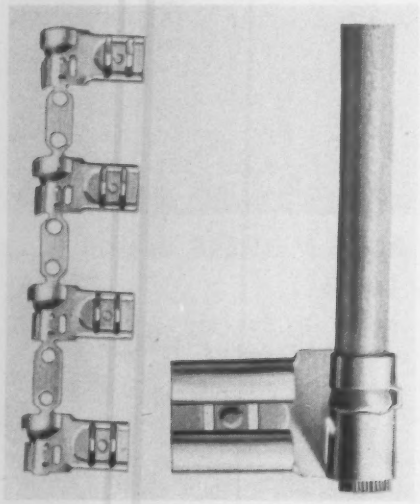
Circle No. **42** *on Reply Card*



Tubeless DC Supply

Employing magnetic amplifier principles, a tubeless, regulated dc supply has high capacity combined with accuracy and reliability. Input is 105 to 125 v ac, single-phase, 60-cycle, and output is 4.5 to 7.7 v dc, adjustable. Load range is 0 to 40 amp, with maximum 1 per cent ripple. Accuracy is ±1 per cent for any combination of line and load conditions. Recovery time under the worst conditions is only 0.2 second. Unit is 17 x 12¼ x 15 in. **Engineering Sales Dept., Sorensen & Co., Inc.,** 375 Fairfield Ave., Stamford, Conn.

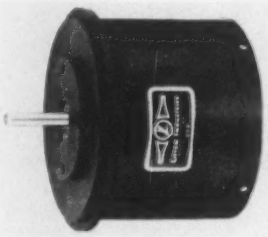
Circle No. **43** *on Reply Card*



Flag Style Connector

New "Flag" connector, added to company's standard line of "push-on" connectors, is said to be the only successful right angle fast connecting terminal to be completely solderless for wire sizes #18 through #12 AWG. Connector accommodates all insulations normally used in automotive and appliance wiring in these sizes. Special feature is the Tab-Lok crimp whereby tab, reinserted through the base web of the terminal during initial stages of crimping, is reformed with the underside of the terminal to provide a reduced section and a voidless crimp on the wire. Reformed tab is locked simultaneously into final crimped position. Keystone serrations give increased tensile strength to connection, and improve corrosion resistance and temperature performance of terminal on both clean and corroded wire. Terminal can be crimped on a center strip, can be used as right or left-handed flag. **Aircraft-Marine Products,** 2100 Paxton St., Harrisburg, Pa.

Circle No. **44** *on Reply Card*



Multi-Turn Potentiometer

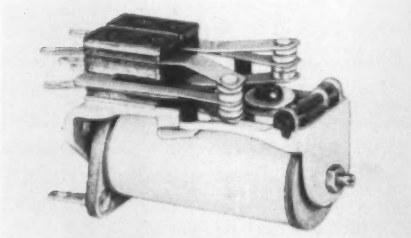
Two new series of high precision multi-turn potentiometers feature excellent linearity and resolution through servo control of resistance winding. Series MA-20-10 has standard independent linearities ranging from ±0.5 to ±0.02 per cent, with as high as ±0.01 per cent available on special order. Resistances are from 1 to 100 K ohms. Series MA-30-10 features standard linearities from ±0.5 to ±0.01 per cent, with as high as ±0.005 per cent available on special order. Resistance range is from 2 to 300 K ohms. Fifteen-turn models are also available. All models have metal housing, 90° electrical and mechanical overtravel at each end of the resistance element, and stainless steel ball bearings and shafts. Overtravel is backed up by a built-in traveling nut type limit stop. Stop is independent of the sliding contact, and resistance element continues through overtravel. Multi-gang versions without external tie rods or brackets, and nonlinear versions can be supplied. **Litton Industries,** 336 N. Foothill Rd., Beverly Hills, Calif.

Circle No. **45** *on Reply Card*

Instrument Servo Motor

A two-phase instrument servo motor is available in two models rated at 1 and 5 w. Both motors are 60-cycle, 115 v. Stator and housing are integrally molded. Motor may be wound with high impedance control windings at additional cost to operate directly from the plates of electron tubes. The 1-w motor may be controlled with a maximum of 3 w since most of the power required is applied to the reference phase. **Diehl Mfg. Co.**, Somerville, N. J.

Circle No. **46** *on Reply Card*



Power Relay

A new power relay is said to be as sensitive and as accurate as a telephone-type relay. It contains silver heavy duty contacts riveted to the spring, and is available with a combination of these heavy duty contacts and standard J twin contacts. Nominal rating is 10 amp, 115 v ac (resistive), and 10 amp, 27½-v dc. Relay has handled inrush currents of 50 amp for 50,000 operations with the dc rating, and has exceeded 500,000 operations with a motor load of 6 amp, inrush current of 15 amp at 70,000 ft altitude. A new hinge-type armature provides adjustment stability. Heavy duty yoke has a stainless steel pivot pin with a large bearing surface which turns in reamed, nonferrous metal bearings. Size is 2¼ x 1⅛ x 1¾-in. **C. P. Clare & Co.**, 4101 W. Pratt Blvd., Chicago 45, Ill.

Circle No. **47** *on Reply Card*

PROBLEM

BUILD A CONVEYOR TO CARRY A 10,000 LB. HULL

ANSWER

Allis-Chalmers Mfg. Company at its LaPorte, Indiana Works required a conveyor which would carry a 10,000 lb. combat cargo-carrier hull through both the painting and finishing operation.

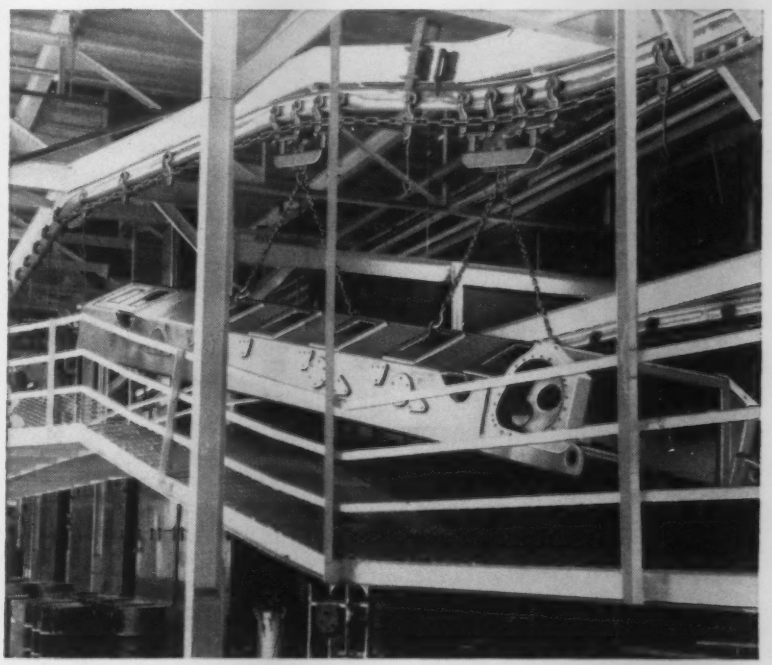
Planet Corporation engineered, designed, and installed the trolley conveyor pictured below which made use of Allis-Chalmers' existing plant facilities.

The Planet X-678 Trolley Conveyor has 6" trolley wheels which run on a 7" I-Beam track, capped with a 12" I-Beam. Because of the tremendous load, the installation is floor supported.

Special load bars, run-away dogs, take-ups, and drives were required, and a safety guard erected capable of withstanding the impact of a falling hull.

Planet also designed and installed additional conveyors to carry the hull through final assembly, as well as the conveyors used on the engine assembly line.

Here's another example of why it pays to "Plan with Planet". If you have need of "automated" equipment to solve a particular production problem why not consult Planet Corporation? *Write today.*



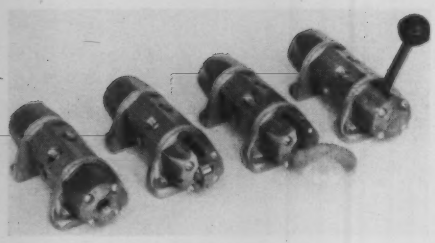
Planet trolley conveyor carrying 10,000 lb. combat-vehicle hull.

WRITE FOR CATALOG

PLANET CORPORATION

1810 SUNSET AVENUE
LANSING, MICHIGAN

- CONVEYORS
- ENGINEERED SYSTEMS
- FOUNDRY EQUIPMENT
- AUTOMATION
- STEEL FABRICATION



Air and Hydraulic Valves

Actuator assemblies are quickly and easily mounted on a new line of manually, mechanically, and pilot actuated "Hi-Cyclic" air and hydraulic valves because of "snap-on" construction of internal parts. Standard hand lever, fingertip or foot lever, piloted, and cam roller actuators are available. Integration of valve components permits quick changeover in the field. Mounting brackets and actuators may be rotated 90, 180, or 270 degrees for mounting and operating the valve in any position. All valve types are available in ⅛, ¼, ⅜, and ½-in. modified NPT ports for use with air, and in ⅛, ¼, and ⅜-in. NPT ports for oil and water hydraulics. **Beckett-Harcum Co.,** Wayne Rd., Wilmington, Ohio.

Circle No. **48** *on Reply Card*

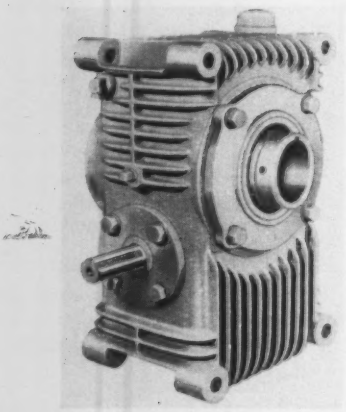
Double Pitch Roller Chains

Long lived, double pitch chains are available for light conveying, material handling and moderate speed power transmission. These standard chains operate on roller chain sprockets, and can be supplemented with stock attachments for use in conveyor lines. **Diamond Chain Co., Inc.,** 402 Kentucky Ave., Indianapolis, Ind.

Circle No. **49** *on Reply Card*

Shaft Mounted Speed Reducer

To provide more horsepower per pound and per cubic inch, shaft mounted speed reducers are equipped with double-enveloping worm gearing. Input and output shafts are designed at right angles to save space. Reducer is mounted directly on driven shaft, requires only a bracket or torque arm to prevent rotation about the shaft. If reducer must be motorized, a bell housing is available for NEMA C-type flanged motors. No couplings are required because tang-type drive sleeve and machined worms provided with the housing will match the motor shaft. No bed plate or mounting arrangement is necessary. Reducer is available with 2, 2½, and 3-in. center distance, and in pinion under, pinion over and vertical shaft models. Re-

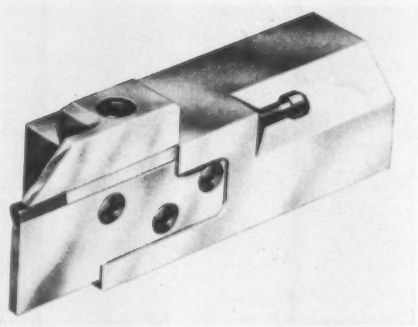


duction ratios in the smaller models are from 5:1 to 50:1, and in the 3-in. size as much as 60:1. Additional output speed reduction is possible when V-belts and sheaves are used in connection to shaft. Loads handled range from fractional to 3, 5½ and 9-hp. **Cone-Drive Gears Div., Michigan Tool Co.,** 7171 E. McNichols Rd., Detroit 12, Mich.

Circle No. **50** *on Reply Card*

Cutoff Tool

Faster, more economical carbide cutting results with use of a new clamp-on tool for cutoff work. Tool is available for turret lathes, automatics, cutoff machines and engine lathes. Special "V" blade support assures accurate location of the carbide cutting insert on center and will not allow "lead off". Tool body does not have to be moved to replace a dull insert and change is said to take only 15 seconds. Adjustable stop provides positive backing to prevent insert from sliding back and acts as means of adjustment after insert has been reground. Interchangeable blade inserts are of molded carbide butt welded to steel shank, and carbide inserts are solid (not tipped),

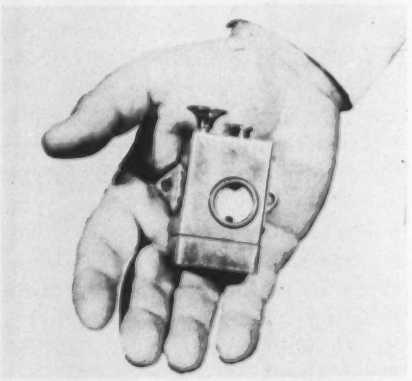


less expensive than standard inserts. **Portage Double Quick Tool Co.,** 1016 Sweitzer Ave., Akron 11, Ohio.

Circle No. **51** *on Reply Card*

Miniature Lubrication System

Smaller than a pack of cigarettes, this special lubricating system contains reservoir, filter, pump, and Meter-Units to serve small machine elements with minimum lubrication demands. Lubricator has been applied successfully to coil winders and rotary index tables. Reservoir holds 20 cc lubricant, and pump is adjusted to discharge 0.6, 0.45, or 0.3 cc whenever plunger is pulled. Unit may be installed to discharge into passages drilled in the machine leading to lubrication points, in which case Meter-Units within the lubricator body proportion lubricant into the various passages in amounts suitable to the bearing being served. Where tubing is used to lead to lubrication points, a single tube usually leads from base of lubricator to junction where branch lines fan out to the lubrication points. In this case the Meter-Units can be installed at the junction or at the point of lubrication. Window in reservoir acts as gage indicating oil level within. **Bijur Lubricating Co.,** Rochelle Park, N. J.



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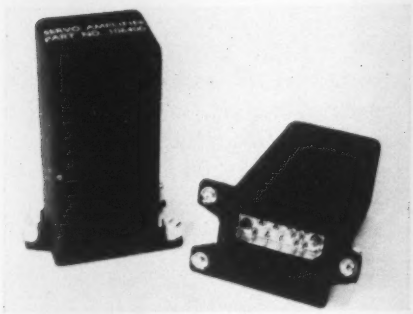
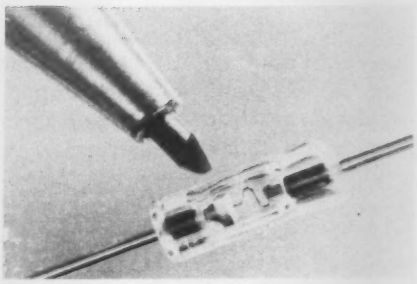


Servo Amplifier and Motor

A miniaturized, plug-in, hermetically sealed servo amplifier controls its companion 400-cycle, 2-phase servo motor to form a "controller assembly" for any servomechanism application. Amplifier can also be used with a polarized relay in very high power discontinuous servos. Amplifier operates directly from the output of a tapped transformer, eliminating need for an external dc source. Maximum plate dissipation is less than 2 w and plate current varies between 5 and 17 ma. Unit has three matched, one-megohm mixing resistors to provide three summed inputs of accurately equal gain. Damped control motor requires 2-w input to the control phase and eliminates tachometer cogging or static error. Servo loop stability is essentially insensitive to line frequency. Motor is available with or without an integral, enclosed gearhead, and ratios can be furnished from 12:1 to 3000:1. Maximum geared output torque is 25 oz-in. **Westbury Div., Servomechanisms, Inc.,** Post & Stewart Aves., Westbury, N. Y.

Circle No. **53** *on Reply Card*



Gold Junction Diodes

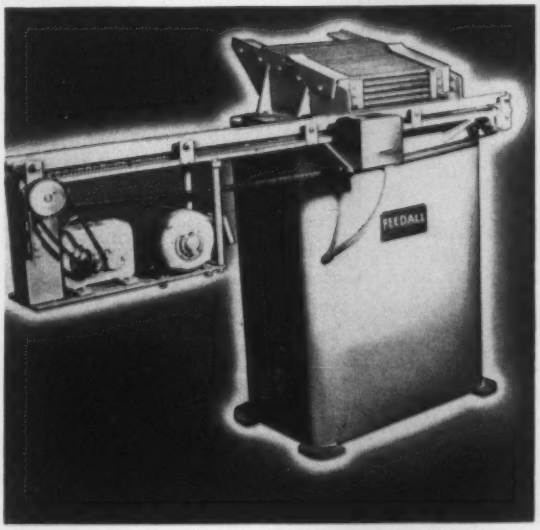
Miniature gold junctions are used in a new line of subminiature germanium diodes. Units are true junction devices, with stable mechanical and electrical characteristics. High forward conductance and high back resistance characteristics suit diodes for use in magnetic amplifier circuits, clamps, dc restorers, and logical gates. One-piece glass body is fusion-sealed, and diode is approximately ¼-in. long and ⅛-in. in diameter. It passes tests for moisture resistance, vibration, and shock. **Semiconductor Div., Hughes Aircraft Co.,** Florence Ave. at Teale St., Culver City, Calif.

Circle No. **54** *on Reply Card*

Packless Solenoid Valve

Line of 2-way solenoid valves may be used to control flow of air, gas, water, light oil, and other noncorrosive fluids. Valves are furnished normally closed or normally open, with standard, watertight, or explosion-proof solenoid enclosures. Currently available pipe sizes are ⅜ and ½-in., and ¾ and 1 in. sizes will be available in a few months. Maximum pressure is 250 psi for normally open, 200

Machines shouldn't be HAND-fed: they should be MACHINE fed . . . with FEEDALL AUTOMATIC HOPPER FEEDS



In conjunction with the above model, we also design and build many special feeders, conveyors, selectors and turnover devices, all of which eliminate expensive hand operations.

Feedall Automatic Hopper Feeds are available in several models and sizes, and are designed to handle a wide range of part sizes. When these units arrive at your plant they are ready to be installed next to the machines to be fed, because they are completely self-contained. Design assembly is so flexible many different combinations are possible to handle a great variety of work pieces. Average feeding rate is 70 pieces per minute—all day long! (Count the cost of hand-feeding, and draw your own conclusions.) Send samples or prints together with your production requirements, and we will send you some welcome information.

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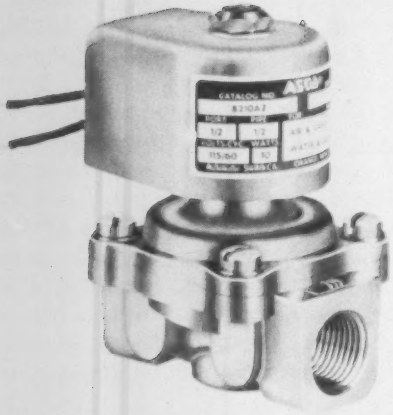
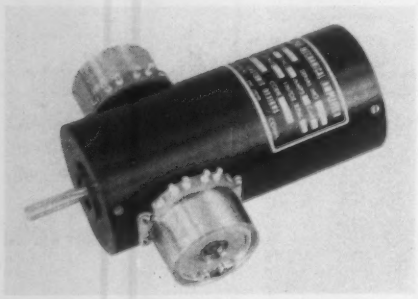


psi for normally closed. Valves may be used on all standard ac and dc voltages, and power consumption is 10 w. All metal parts contacting fluids are of brass or stainless steel to prevent corrosion. For severe applications glass silicone insulated coils, luxolene molded coils, and plastic covered coils are available. Internal parts on the pilot are accessible without removing valve body from pipe line. **Automatic Switch Co.,** 391 Lakeside Ave., Orange, N. J.

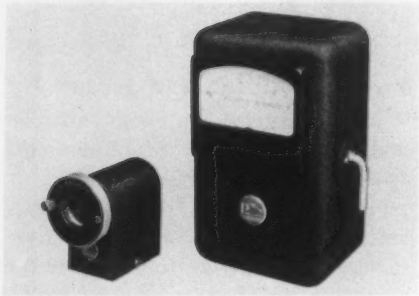
Circle No. **55** *on Reply Card*



Amplifier for Servo Motors

Electromechanical amplifier acts as motor control for computers and calculators, guided missiles, radar equipment, aircraft, and servo motor applications. With a relatively small amount of power, 50 to 100 milliwatts, amplifier can control a large motor. Unit features proportional control of the output shaft which will rotate either clockwise or counterclockwise. Planetary gearing and stationary dry magnetic clutches eliminate powder packing and slip rings. Commercial gears are used rather than expensive close tolerance gears. Additional features are zero backlash, high torque-to-inertia ratio, and minimum overshooting. Amplifier is rated at 5 in.-lb torque at 60 rpm, and is available for most standard line frequencies and voltages. **Electomic Designs,** Greenwich, Conn.

Circle No. **56** *on Reply Card*



Photoelectric Pyrometer

Precise monitoring and control of temperature of hot materials is provided by a new photoelectric pyrometer. System consists of two units; a scanner made up of a phototube and lens assembly, and a control unit containing an electronic amplifier, a relay, and a meter. The control operates from the amount of infra-red radiation emitted by the hot object. As the temperature of the object being scanned rises, the radiation increase is indicated on the meter. Fast-acting relay can control heat being applied to the material at any point throughout the range of the set. The point at which the relay operates can be preset to provide automatic control of signal devices or of the heat applied to the material. Since equipment does not touch the hot object, the system can measure temperature of moving objects and units which are surrounded by heating coils or are otherwise difficult to measure conventionally. A recorder can be connected into the circuit to provide a continuous chart of temperature variations. Measuring and control range is 1000 to 5000°F, power supply is 115 or 230 v, 50 or 60 cycles, and power consumption is 12 w. Typical applications include use in induction heating, welding, wire drawing, rolling mills, laboratories, and industrial ovens. **Dept. P198, Photoswitch Div., Electronics Corp. of America,** 77 Broadway, Cambridge 42, Mass.

Circle No. **57** *on Reply Card*

new catalogs..... latest literature

Let us get them for you

Here is the latest in automation "how-to"—yours for the asking.

Automated Sheet Metal Handling

Fried Steel Equipment Mfg. Corp.—A line of strip and materials handling devices for automating sheet metal plants and warehouses includes a Stripveyor to pick up and carry strips beyond shear bed as fast as they are sheared, a Strip-Stacker to stack and store the strip, a Liftveyor to support sheet being cut to tolerances as close as 0.005-in. and to counteract flexing. Eight-page bulletin illustrates and describes three basic machines fully, includes brief summary of an auxiliary scrap eliminator and beltveyor for short shearings.

Circle No. 58 on Reply Card

High Speed Precision Indexing

Ferguson Machine & Tool Co., Inc.—Trans-o-Mator, production tool designed for retooling with drilling and tapping heads, air clamps, presses, electronic devices, eccentric or cam operated levers, light machining, forming, pressing and assembly inspection operations, is discussed in four-page brochure. Photographs of models, specifications and data on several models are also given.

Circle No. 59 on Reply Card

Directional Control Valves

Industrial Hydraulics Div., Parker Appliance Co.—Ten-page catalog file describes five hydraulic directional control valves for mobile equipment applications. One, two, three and four-spool models for eight to 35 gpm are covered in photographs, sketches and dimensional charts.

Circle No. 60 on Reply Card

SR-4 Devices and Equipment

Baldwin-Lima-Hamilton Corp. — Discussion of devices and equipment employed to measure, indicate and record physical quantities is given in 20-page illustrated bulletin. Equipment falls into three basic classes: load cells and load beams, fluid pressure cells, and torquemeters. Photographs show various applications; sketches and specifications are also included.

Circle No. 61 on Reply Card

Oxygen Recorder

Hays Corp.—Magno-therm oxygen recorder, consisting of analyzing section electrically connected to a remote mounted recording section, is the subject of 16-page, illustrated brochure. Recorder can be used for flue gas analysis, process and product control and as safety device to measure oxygen in conveying, heating and compressing explosive gases. Brochure contains charts, photographs and specification data on unit.

Circle No. 62 on Reply Card

Standard Tools and Machines

Zagar Tools, Inc.—Zagar engineering equipment for drilling, milling, tapping and broaching is described in an eight-page brochure. Among standard and semi-standard equipment are: gearless drill heads, self-clamping drill jigs, feed units, heavy duty drilling machines, hydraulic broaching machines, special drilling machines, collets, holding and indexing fixtures, and lathe chucks. Bulletin gives pictures, general specifications and applications of equipment.

Circle No. 63 on Reply Card

Repeat Cycle Timers

A. W. Haydon Co.—Information on new line of miniature hermetically-sealed repeat cycle timers is given in this bulletin. Cycling time, timing accuracy, detail characteristics and determination of timing tolerances complete the material.

Circle No. 64 on Reply Card

Silicon Transistors

Texas Instruments Inc.—Descriptive data sheets present mechanical and electrical data, and operating conditions for a medium power and two general purpose silicon transistors. Silicon models are said to offer higher power output and be more independent of ambient temperatures than germanium counterparts. New transistors operate up to 150° C with current amplification essentially independent of temperature change.

Circle No. 65 on Reply Card

Conveyor Rolls

Boxley Co.—"Z" design conveyor rolls, used for moving raw materials to machines and parts in process between operations, are the subject of a four-page illustrated brochure. Rollers continuously conform to varying contours of moving load, and are supplied in either soft or medium grade oil-resistant synthetic rubber, with ½-in. socket head cap screws, tube-type spacers, and self-locking jam nuts.

Circle No. 66 on Reply Card

Ledeen Valves

Ledeen Mfg. Co.—Line of standard, 4-way hand, foot, power and solenoid operated valves is the subject of a 16-page bulletin. Also discussed is a new line of pilot valves. Dimensions and weights, application diagrams, circuit diagrams, parts list and accessories are covered.

Circle No. 67 on Reply Card

Conveyors

Metzgar Conveyor Co.—Thirty-six page catalog gives thorough coverage to Metzgar line of conveyors. Gravity conveyors, gravity roller and wheel conveyors, gravity stands, bases, switches and spurs, power conveyors and controls, and auxiliary equipment are discussed. Photographs, charts, sketches and specification data complete this catalog.

Circle No. 68 on Reply Card

Screw Holding Accessories

Magna Driver Corp. — Twenty-five page manual on magnetic screw holding accessories for power screw drivers and nut setters includes complete specifications data, selection information, and photographs of various models. Using the force of high energy permanent magnets for holding screws, bolts or nuts in assembly operations is outlined.

Circle No. 69 on Reply Card

Loadmeter

Detroit Milling Cutter Co.—Described as the "arch enemy of tool breakage, machine breakdown and work spoilage", loadmeter is mounted on any type of motor driven equipment, indicates trouble, then instantly shuts off motor, feed, or whatever is necessary in individual case. Models L100 and L122 are furnished with 8' leads. Four-page, two-color brochure contains pictures, descriptions, installation instructions, and prices of three models.

Circle No. 70 on Reply Card

Eddy Current Rotating Equipment

Dynamatic Div., Eaton Mfg. Co. — Eddy-current rotating equipment, used to generate torque, is discussed in illustrated, 16-page bulletin. Adjusto-speed drives, liquid and air-cooled couplings, absorption, motoring, universal and variable frequency dynamometers and press drives are covered. Photographs of equipment in operation, and detailed material on their basic principles are included.

Circle No. 71 on Reply Card

Automatic Shovel

Hamilton Automation, Inc. — Illustrations and specifications of automatic shovel are included in this bulletin sheet. Shovel is air operated, removes parts from punch press dies automatically and is a self-contained unit.

Circle No. 72 on Reply Card

Magnetic Particle Clutches, Brakes

Vickers Electric Div., Sperry Corp.—Four-page bulletin describes "Magneclutch" line which operates on a magnetic particle principle. Clutch transmits torque through the magnetic medium to provide smooth acceleration, may be operated manually, by adjustable resistor, potentiometer, or automatic control. Gears, sprockets, linings, pressures and other mechanical clutching devices are eliminated. Magnebrake provides preset or adjustable braking, from full speed to standstill, without grab or friction wear. Suggested applications include conveyors, dynamometers, automatic lathes, pumps, separators, and vibrators.

Circle No. 73 on Reply Card

Oxygen-Free Atmosphere

Arnold A. Beckman, Inc.—Accurate instrumentation and process regulation provide inert, oxygen-free gases to heat treating, welding, sintering and coating of metals. Bulletin listing and describing necessary equipment is titled "Atmosphere Furnaces."

Circle No. 74 on Reply Card

Knu-Vise Products

Lapeer Manufacturing Co.—Complete line of Knu-Vise products such as clamps, pliers and wrenches are outlined in this 26-page bulletin. Air-operated automatic clamps with toggle-bar forces up to a ton of pressure are covered. Clamps are designed for single installations, multiple installations controlled by a single valve, and multiple installations with sequence valve. Bulletin includes specifications, price list and pictures of models.

Circle No. 75 on Reply Card

Screwdriving Machines and Equipment

Detroit Power Screwdriver Co.—Thoroughly-illustrated, 40-page bulletin discusses complete line of screwdriver machines, fixtures, hopper units, nut drivers, and special assembly machines. Specifications, descriptions, applications, photographs and dimensional layouts of various models are included in this comprehensive bulletin.

Circle No. 76 on Reply Card

new catalogs..... latest literature

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Rotary Indexing Table

Erickson Tool Co. — New indexing unit, equipped with plain 10-inch diameter dial and designed for use in a vertical position is described in four-page, two-color bulletin. Indexing table features easy division changes —to 4, 6, 12 or 24—through insertion of stop screw in tapped hole. Bulletin includes pictures, dimensions and two-page price list insert.

Circle No. 77 on Reply Card

Balancing Machines

Balance Engineering Co.—Eight-page bulletin covers new series of nine heavy duty, general purpose static and dynamic balancing machines for small and medium size motors. Machines can be used to balance armatures and rotors, impellers, blower wheels, flywheels, fans and pulleys. Capacity specifications, dimensional data, sketches and photographs of machines in operation complete the bulletin.

Circle No. 78 on Reply Card

The Con-Tour

Continental Tooling Service, Inc.—Second issue of bi-monthly, four-page external house organ of Continental Tooling Service covers three case histories of work in product engineering and tooling. Brochure includes photographs and data on company installations.

Circle No. 79 on Reply Card

Automation of Machine Tools

Turchan Follower Machine Co.—Comprehensive 24-page booklet covers automatic control systems for machine tools and servo-controlled machine tools. One, two, and three-dimensional control systems are shown in sketches. Ten pages of photographs illustrate actual installations of servocontrols on variety of conventional machine tools, with specifications of machine tools indicated.

Circle No. 80 on Reply Card

General Purpose 2-Way Valve

Automatic Switch Co.—Pertinent data on 2-way, internal pilot operated solenoid valves is set forth in a 4-page bulletin. Valves control flow of air, gas, water, light oil, and other noncorrosive fluids, and can be applied to instrumentation, machine tools, and appliances. Dimensional diagrams, flow charts, and list prices included.

Circle No. 81 on Reply Card

Adjustable Relays

A. W. Haydon Co.—New line of hermetically-sealed adjustable time delay relays for military operations under severe environmental conditions is discussed in a two-page catalog sheet. Details on housings, settings, motors, operations, calibration, and hermetic sealing are included. Diagrams and chart give specifications of relays.

Circle No. 82 on Reply Card

Potentiometer Handbook

Technology Instrument Corp.—This comprehensive 234-page loose-leaf publication proves an informative guide for the users of precision potentiometers. Divided into two sections, handbook and catalog, it gives thorough coverage to the basic elements of a precision potentiometer, its terminology, characteristics, and applications. The catalog section includes a complete description of the TIC precision potentiometer line and the entire book is supplemented with sketches, charts and specifications sheets.

Circle No. 83 on Reply Card

Chipless Machining

Michigan Tool Co.—New "chipless machining" process for cold-forming splines, serrations and similar forms is outlined in four-page illustrated bulletin. Background of this new metalworking technique, called "Roto-flow" is given, along with tooling, parts formed, automation of the cold-forming machines, typical applications and design advantages.

Circle No. 84 on Reply Card

Comprehensive Conveyor Parts Catalog

Link-Belt Co.—A new 340-page catalog has thumb index to provide easy and rapid selection of standard products. Major product classifications include chains and sprockets for conveying, elevating and power transmission; enclosed gear drives and variable speed drives; ball and roller bearings, babbitted bearings, pulleys, gears, clutches, and couplings for power transmission; components for screw, belt, oscillating and bucket conveyors. Capacity charts and dimension tables aid in selection of products.

Circle No. 85 on Reply Card

Ransomatic

N. Ransohoff, Inc.—Compact machine, the Ransomatic combines all necessary processes for efficient washing, pickling and neutralizing of metal parts automatically prior to plating. Machine has vertical centrifugal packless pumps to minimize problem of pumping, cleaning and pickling solutions, adjustable trunnions, chip baskets which strain all liquids, and requires only one sewer connection. Four-page bulletin includes diagrams and photographs of machine.

Circle No. 86 on Reply Card

Computer Analysis of Instruments

Beckman Instruments, Inc. — "Computer Techniques in the Instrumentation Industries" is a five-page bulletin covering use of analog computer in design and control problems of instrumentation. An explanation of techniques involved in dynamic analysis of an instrument in use with its associated equipment shows simulation of process control systems and use of analog computer. Galvanometer and process control simulation and an analysis of a motor controller are demonstrated.

Circle No. 87 on Reply Card

Monitor and Control Instruments

Consolidated Engineering Corp.—Electronic instrumentation is applied to petroleum, chemical, and medical uses, pressurized and vacuum product testing, and continuous, automatic monitoring and control of gas or liquid flow lines for evaluation of products and processes. Catalog enumerates case histories for various industries with good illustrations in 22 pages, and includes descriptive data on company's control and test instruments.

Circle No. 88 on Reply Card

Variable Speed Drive

Speed Control Div., Fairchild Engine & Airplane Corp.—Attractive six-page bulletin describes Specon electrical differential drives, which maintain efficiency by keeping part of power flowing directly through the gears to the output shaft and maintain full-rated torque at all speeds including zero. Drive can be manufactured in any size required from fractional hp to several hundred hp. Bulletin contains dimensions, ratings and color pictures of various models.

Circle No. 89 on Reply Card

Bridge Cranes

Michigan Crane & Conveyor Co.—Single, double and box girder cranes are outlined in six-page brochure. Cranes are equipped with anti-friction bearings, fluid drive for crane and load protection. Specifications data and photographs are given in the bulletin.

Circle No. 90 on Reply Card

Turret Indexing Units

Swanson Tool and Machine Products, Inc.—Ten-page brochure describes turret indexing units which provide a completely self-contained turret chassis in a wide range of turret diameters, speeds and stations. Standard units with turret diameters of 20, 30, or 40 inches for mounting 16, 24, or 32 work stations, and with indexing rates from 547 to 4,700 per hour are available. Operational data, dimensional details, and sketches of various models are included.

Circle No. 91 on Reply Card

Dimensional Inspection

Federal Products Corp.—Thirteen-page booklet, "A Management Blind Spot", discusses use of dimensional control by management to cut losses and increase profits. Fixed tolerances on blue prints and quality control are among suggestions given in actual case histories of application of dimensional control.

Circle No. 92 on Reply Card

Controlled Volume Pumps

Milton Roy Co.—Twenty-page bulletin describes use of controlled volume pumps as flow controllers, ratio controllers and final control elements in process instrumentation. Types, operation and applications of pumps in chemical, petroleum, paper, food, water treating and other industries are included, along with engineering data.

Circle No. 93 on Reply Card

Overhead Conveyors

Flex-I-Line Conveyor Corp.—Four-page bulletin describes three models of overhead conveyors which are adaptable to all Monorail installations. Segmented cable in conveyor permits positive bracket positioning, sharp dips and turns. Photographs and specifications complete the brochure.

Circle No. 94 on Reply Card

Automatic Cylinders

Miller Fluid Power Co.—Well-illustrated, 12-page booklet describes standardization of critical cylinder mounting dimensions and stroke lengths, interchangeable mountings, complete line of bores, strokes and models for

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custom requirements and heavy duty cylinders —all built for automation. Comprehensive drawings and tables demonstrate large degree of standardization of critical mounting dimensions between various cylinder manufacturers, and internal fluid pressure stresses of essential cylinder components.

Circle No. 95 on Reply Card

Industrial Relays

Automatic Electric Sales Corp.—Ten data sheets cover complete line of industrial relays which are plug-mounted for advantages in assembly, inspection, servicing and maintenance. Dimensional drawings, wiring diagrams and specifications for five different plug-mounted classes of relays are given.

Circle No. 96 on Reply Card

Automatic Equipment Installations

Bodine Corp.—Twenty-eight page brochure describes 12 actual case histories of how Bodine automatic equipment is used by various manufacturers. Each history gives illustrations of the machine involved and the part made, drawings of the sequence of operations, production capacity, specifications and other data. Machines in installations include automatic multi-spindle machines for drilling, tapping, milling, screw inserting and assembly of small parts.

Circle No. 97 on Reply Card

Consolidated Systems Engineering

Consolidated Engineering Corp.—Case histories of typical instrumentation systems, applications and descriptions of service facilities are given in 16-page bulletin which describes role of Systems Div. of Consolidated Engineering Corp. Custom engineering of electronic instrumentation for specific industrial, scientific and military needs is illustrated in photographs and sketches.

Circle No. 98 on Reply Card

Multi-Spindle Machine

Bodine Corp. Model 40-10 automatic dial-feed multi-spindle machine, used for tapping and screw inserting operations in industries where mass production of small interchangeable parts is required, is discussed in 16-page bulletin. Also covered are design features, manufactured parts, case histories, operating instructions and maintenance information on the machine. Isometric, exploded and silhouette drawings illustrate both operation and parts.

Circle No. 99 on Reply Card

Frequency Counter and Totalizer

Detectron Corp.—Electronic pulse indicator which counts and displays any electrical or mechanical event that can be converted to electrical impulses from 10 to 100,000 events per second is covered in two-page brochure. Totalizer, discussed in second bulletin, automatically records pulses separated by only five micro-seconds and requires no voltage regulation. Both brochures contain photographs, specifications and price lists.

Circle No. 100 on Reply Card

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New Catalogs & Literature

Monitoring Transduction Ratio

Statham Laboratories, Inc. — "Instrument Notes No. 28" discusses technique for establishing span and zero of transducers for each recording channel during flight test. Material is taken from paper, "A New System for Monitoring the Over-All Transcution Ratio for Analog Recording Channels Employing Bridge Type Transducers" by Arthur T. Snyder of Boeing Airplane Co.

Circle No. 101 on Reply Card

Nuclear Controls and Measurements

Industrial Nucleonics Corp.—AccuRay gages for continuous sheet process industries, off-on and proportional controllers, and gage consoles containing recorder, measuring circuit, source safety alarm, power supplies, amplifier and circuit checking system, are covered in 16-page bulletin. Main components in gage are source of radiation, radiation detector and recording device. Brochure includes photographs, sketches and specifications.

Circle No. 102 on Reply Card

Computer Components

Librascope, Inc.—Four-page brochure outlines line of mechanical and electrical computer components. Among units described with photographs and specifications are hollow shaft differential, ball and disc integrator, sine-cosine mechanism, linkages, analog digital converter, read-record heads and magnetic decision elements. Components can be used in manufacture of electromechanical analog computers, industrial automatic control and data handling systems.

Circle No. 103 on Reply Card

Highlights in PEC Progress

Patterson, Emerson, Comstock, Inc.—Pictures and descriptions of company products and achievements comprise this 44-page bulletin. PEC electrical construction installations in boiler houses, switchyards, substations, arc furnaces and strip mills in operation are among illustrations. A list of PEC's principal clients is also included.

Circle No. 104 on Reply Card

Standard Automation Units

Wilson Automation Co.—The concept of automation and some of its standard units manufactured by Wilson are the subject of this 17-page bulletin. Units such as control-section transfer, gate transfer, turnover, lengthwise transfer and turnaround are pictured. A typical automation plant layout, which is included in a Wilson project study booklet is also shown.

Circle No. 105 on Reply Card

Power Spray Washers

Peters-Dalton Inc.—Spray washers, designed for use in metal-working industry are the subject of this 15-page bulletin. Washers can be used on television tubes, heavy machined parts, rotary shells, meat hooks, helical drums and numerous other types of equipment. Layouts and applications, along with 15 engineering drawings of most commonly used washers are included.

Circle No. 106 on Reply Card

Telemetering Booklet

Bristol Co.—Almost 100 photographs illustrate applications of a line of Metameter telemeters to measurement and transmission of pressure, flow, liquid level, mechanical motion, electrical units and totalized power load in a 44-page booklet. Telemetering over telephone circuits, carrier current, and private wires is featured, as well as microwave, time multiplexing, and selective calling. Metagraphic recorders and indicators for use as metameter receivers on graphic panels and consoles are included.

Cirice No. 107 on Reply Card

Correction and Variable Transmissions

Machine-O-Matic, Inc.—Single unit variable and correction transmissions are the subject of a four-page bulletin which includes sketches, charts and diagrams. Units permit splitting of single tooth on a change gear, and act as vernier adjustment when used with other variable transmissions. Correction transmissions are designed to operate with electronic controls.

Circle No. 108 on Reply Card

Tools of Automation

Reliance Electric & Engineering Co.—Automation of single machines or continuous processes is discussed in this 12-page bulletin. Separate sections are devoted to precision built motors, V-S drives, controls and regulators with pictures and data covering each. Final section includes captioned photographs which illustrate automation at work in many industries.

Circle No. 109 on Reply Card

Multiple Liquid Filler

Arthur Colton Co., Div., Snyder Tool & Engineering Co. — Specification sheet describes liquid, paste, and cream fillers for bottles, cans, tubes and jars, with indexing rotary table for use with standard conveyor belt. Unit is designed for production line applications and fills four to 12 containers at one time. Sheet gives specifications, operational data and photographs of several models.

Circle No. 110 on Reply Card

Temperature Control

Burling Instrument Co. Inc.—Two-page bulletin describes Model D-18, temperature control for use in controlling temperatures up to 1800 degrees, where wide and easily adjustable range is required. Instrument operates by the differential expansion of solids and has two-sectional inner tube. Bulletin includes photographs, specifications and sketches of the instrument.

Circle No. 111 on Reply Card

Material Handling Equipment

Jeffrey Mfg. Co.—Material handling and processing equipment is the subject of a comprehensive 43-page catalog. Among equipment discussed are vibrating feeders, weight feeders, vibrating conveyors and barrel packers, magnetic separators, spiral, apron and belt conveyors, bucket elevators and power scoops. Photographs of equipment in operation, data on various models and specification information are included.

Circle No. 112 on Reply Card

Process Instrumentation

Fischer & Porter Co.—General catalog, 12 pages, outlines company line of process instrumentation. Instruments for flow-rate measurement, pressure, temperature, liquid level, density, viscosity, transmission, pneumatic control and regulation are discussed. Illustrations, descriptions and basic specifications complete the brochure.

Circle No. 113 on Reply Card

Computers and Plug-in Components

Servomechanisms, Inc.—Computers, components and control systems are discussed in 12-page, illustrated bulletin. Brief summary of company history, design, philosophy and general facilities, along with numerous photographs, are included. Among computers and components discussed are: Mach computers, master air data computers, accelermeters and positioning mechanisms.

Circle No. 114 on Reply Card

Recording Oscillograph

Consolidated Engineering Corp. — Twelve-page bulletin describes recording oscillograph which has rapidly interchangeable daylight-loading magazines, positive gear drives, wide record-speed range and selection of galvanometers. Instrument can provide direct graphical presentation of large quantities of data, simultaneously and with positive time correlation under extreme environmental conditions. Photographs, sketches and specification charts complete the bulletin.

Circle No. 115 on Reply Card

Lubricating Systems

Trabon Engineering Corp.—Fifty-five page catalog is collection of brochures issued by Trabon which describe various lubricating systems. Included is material on manifold and reversible systems, lubricant, hydraulic, and motorized pumps, spra-lube valves, feeder selection chart. Photographs, sketches, charts, parts lists and general data complete comprehensive catalog.

Circle No. 116 on Reply Card

Injection Molding Machine

F. J. Stokes Machine Co.—Four-ounce automatic injection molding machine which gives positive ejection and produces finished degated pieces is discussed in four-page, two-color brochure. Sequence of seven photographs illustrate positive ejection of pieces and runners, de-gating and separation of finished parts from sprues and runners. Specifications and details of construction and operation are also given.

Circle No. 117 on Reply Card

Worm Gear Motors and Reducers

D. O. James Gear Mfg. Co.—Two illustrated catalogs describe worm gear motors and gear motor reducers. Both are designed for horizontal or vertical drive. Motors' ratio range is 5.66:1 to 100:1, and ⅛ to 30 hp. Motor reducers available in 35 sizes, with ratio range of 10:1 to 1200:1 and ¾ to 75 hp. Catalogs include rating tables, dimensions and prices.

Circle No. 118 on Reply Card

Stepping Relays

Guardian Electric Mfg. Co.—Illustrations, dimensional drawings and technical chart data are given in 12-page booklet discussing stepping relays. Twelve types of Guardian relays, including midget, high speed, vibration resistant and interlock are covered.

Circle No. 119 on Reply Card

Subminiature Capacitors

Hopkins Engineering Co.—Bulletin outlines Hy-Therm subminiature, hermetically sealed capacitors which are used for applications requiring high insulation resistance and stability at high temperature. Size and performance details are given in the brochure.

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Weigh Feeder

Exact Weight Scale Co.—Calibrated, precision weigh feeder for use on injection molder is discussed in 12 pages. Unit feeds necessary amount of plastic material required and has vibratory feeder and electric controls. Material on weigh feeder is divided into two illustrated, four-page brochures and article, "Weigh Feeding", from Dow Chemical Co.

Circle No. 121 on Reply Card

Automation Engineering Bulletin

CDC Control Services, Inc.—Solution of a difficult pressure control problem related to a blowdown tunnel is outlined in four-page bulletin. Problem, specification and method of solution used by CDC, along with photographs, block diagrams and sketches complete the brochure.

Circle No. 122 on Reply Card

Relief Valves

Fluid Controls, Inc.—Spring loaded, guided piston relief valves, of ¼ and ⅜-inch pipe sizes are the subject of two catalog sheets. Valves are used to control pressure in clamping or feed circuits. Sketches and dimension charts are used to describe the valves.

Circle No. 123 on Reply Card

Silver-Zinc Batteries

American Machine & Foundry Co. Six-page, two-color brochure describes advantages and features of silver-zinc batteries, available in single and multiple cell construction. Batteries have uniform discharge of voltage, high drain rates and high power output per unit volume. Technical data charts and specifications are included in the brochure.

Circle No. 124 on Reply Card

High-Speed Microoscillograph

Central Research Laboratories, Inc. Four-page brochure discusses single-sweep recording of three simultaneous phenomena at frequencies up to 10,000 megacycles made possible with Model 2 high-speed microoscillograph. Micro-electron-optical technique of instrument to achieve a proportionally higher cut-off frequency using a travelling-wave deflection system is described. Also included are details on operations and specifications of microoscillograph.

Circle No. 125 on Reply Card

Constant Voltage Transformer

Sola Electric Co. Theory of design and operation of constant voltage transformers is dealt with in this 20-page publication. Schematic and vector diagrams, performance curves and photographs illustrate typical assemblies of transformer. Booklet discusses modifications for harmonic neutralization, compensation for variable frequency and modifications for regulated multiple output for electronic supply.

Circle No. 126 on Reply Card

Time Delay Relays

AGA Div., Elastic Stop Nut Corp. of America. Two-color bulletin describes two types of the Model NEH Agastat time delay relay, with double-throw auxiliary switch which allows push-button operation, or instant or delayed contacts after deenergization. Bulletin also gives dimensions, mounting and terminal arrangements, and wiring diagrams.

Circle No. 127 on Reply Card

Automatic Lubrication

Bijur Lubricating Corp. Three basic elements of automatic lubrication—lubricators, distribution systems and meter units—are described and illustrated in this four-page brochure. Eight types of automatic lubricators are covered, with a basic description of a typical pump and reservoir assembly. Information on tubing, junctions and flexible hoses in distribution systems, along with cut-away view of internal construction of filter, metering orifice and check valve of meter unit are included.

Circle No. 128 on Reply Card

Hydraulic Components

Wisconsin Hydraulics, Inc. Informative eight-page folder describes hydraulic motors, gear-type pumps, valves, cylinders, and valve and pump combinations for up to 1000 psi working pressure. Motors and pumps in a number of mounting variations are available in sizes ranging from 8 to 22 gpm at 1000 psi. Large diameter single and double acting hydraulic cylinders, in sizes from 5 to 8-in. diameters are presented along with charts giving operating pressures and dimensions.

Circle No. 129 on Reply Card

Commutator Motors

Electric Indicator Co., Inc. Twenty-two page brochure is reference on physical and electrical characteristics for "Elinco" line of commutator motors and governor units. Included are sections on field, shunt and universal wound motors as well as permanent magnet and separately excited types. In addition, performance curves, dimensional drawings and specifications are given for each type listed.

Circle No. 130 on Reply Card

Turbo Products Catalog

William Brand & Co. Forty-four page catalog gives specific information concerning wires and cables, plastic tubing, coated tubing and sleeving, and identification markers manufactured by William Brand & Co. Appendix defines technical terms, and tables of insulation resistance temperature coefficients and temperature conversion are included. Photographs show various products in application.

Circle No. 131 on Reply Card

Electric Motors

U. S. Electrical Motors, Inc. Multi-color booklet illustrates 20 principal types of U. S. motors, including uniclosed, totally-closed, varidrive, synchrogear, right-angle worm gear, verticlosed holloshaft, etc. Also covered are auto-start buffers, right-angle holloshaft gear drive for turbine pumps, lubriflush transverse bearing lubrication, asbestos-protected windings and normalized motor castings.

Circle No. 132 on Reply Card

Delay Lines

Richard D. Brew & Co. Illustrations, descriptions and technical data covering the lumped constant, distributed constant and ultrasonic delay lines are given in an attractive 12-page brochure. Testing procedure of delay line for quality control is also included.

Circle No. 133 on Reply Card

Machine Tool Life Control

Royal Design & Mfg. Inc.—"Cy-Co-Trol" is a control unit which is installed at a machine tool to indicate stage of tool life by "cyclemeters." When tool has reached last 10 per cent or last hour of operating life a yellow signal turns on and a relay is energized which breaks cycle control circuit of machine, requiring operator to recycle and change tools. Four-page bulletin gives information and diagrams of typical tooling applications.

Circle No. 134 on Reply Card

Electronic Relay

Machinery Electrification, Inc. Bulletin covers description, specifications, application, installation and replacement parts of the MEK-2052 electronic relay. Relay is designed for high-sensitivity operation, and recommended for liquid level control, gauging operations or positioning. Diagrams showing normal and reverse operation, different mountings, and socket connections of the relay complete the 9-page bulletin.

Circle No. 135 on Reply Card

Settling and Filtration System

Industrial Filtration Co. — A combination settling and filter system for the continuous removal of chips, heavy solids, and relatively fine solids to 0.004-in. screening is described in a 4-page bulletin. System expels settled solids by means of chain driven flights, thus reducing the volume of solids to be removed by the filter screen. Cutaway view of the unit shows complete operation.

Circle No. 136 on Reply Card

Power Transmission Components

Morse Chain Co.—Mechanical power transmission products are described in an 8-page bulletin which includes stock sizes, specifications, and applications for each product. Typical items are silent and roller chains, Hy-Vo drives, sprockets, cable chain, drive shafts, couplings and clutches.

Circle No. 137 on Reply Card

Infrared Spectrometer

Perkin-Elmer Corp.—Six-page bulletin gives operating data, illustrations, graphs, and specifications on a single beam, double pass, recording infrared spectrometer. Addition or removal of a source, detector, prism assembly, etc., quickly adapts the machine to any radiation range or type of sampling problem. Operation is possible in the ultraviolet, visible, near infrared, fundamental, and far infrared regions.

Circle No. 138 on Reply Card

Materials Handling Racks, Fixtures

Imperial Rack Co., Inc.—"Finger-Tip" catalog on Naraco racks, fixtures, work-holders, and tips for plating processes and materials handling contains 20 pages illustrating racks and tips. In addition to these large lines, the company also furnishes conveyor and heat treat hooks and racks, masking molds, and rubber masks.

Circle No. 139 on Reply Card

Engineering Planning

Giffels and Vallet, Inc. Sixteen-page bulletin describes progress of Giffels and Vallet over 30-year period. Engineering planning services, representative projects and pictures of layouts developed by company are given.

Circle No. 140 on Reply Card

Plastics Injection Molding Machine

Hydraulic Press Mfg. Co. Line of machines for molding polystyrene, acrylics, cellulose acetate, cellulose acetate butyrate, elastomeric vinyls, nylon and other thermoplastics is subject of this 12-page bulletin. Full specifications on all injection machines ranging from 6-oz. capacity to 400-oz. capacity and 3000 ton mold clamping force are given.

Circle No. 141 on Reply Card

Duplex Function Plotter

Minneapolis-Honeywell Regulator Co.—ElectroniK recorder, which automatically plots a curve that continuously evaluates two variables in terms of a third on a single chart, is described and illustrated in data sheet 10.0-17. Instrument consists of three complete measuring and balancing circuits, can be energized by any dc millivolt source.

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Process Monitor Spectrometer

Consolidated Engineering Corp. Mass spectrometer, Model 21-610, a precision electronic instrument, is designed to measure amount of various constituents in a process stream. Eleven-page bulletin outlines functions of basic instrument, produced especially for chemical, petroleum and gas industries, and its accessories. Specifications and standard feature chart of mass spectrometer complete this bulletin.

Circle No. 143 on Reply Card

Spectrochemical Analysis Units

Jarrell-Ash Co.—Five types of precision excitation units for spectrochemical analysis are described in an 8-page catalog. Design features and illustrations supplement tables which give relative qualities and parameter specifications of the five circuits. Units can be used with any prism or grating spectrograph.

Circle No. 144 on Reply Card

Roll Shaft Design, Deflection

Rodney Hunt Machine Co.—Three formulas for calculating maximum bending of shaft, maximum stress set up by bending moment, and deflection of shaft between roll and bearing are given in this report, third in a series on basic engineering data on industrial rolls.

Circle No. 145 on Reply Card

AUTOMATION

ABSTRACTS

CONTROLLING THE ELECTRIC ARC

C. W. VOKAC
Whiting Corp.
Harvey, Ill.

THE ELECTRIC-ARC furnace is a significant part of our economy. Its applications appear to be increasing at an unparalleled rate. That progress is due to the co-operative, competitive and ceaseless efforts of many industries, professions, and trades. Among them are the furnace builders who strive continuously to improve the arc-furnace equipment, reduce its costs, and improve its efficiency and operability. Thus, the arc furnace is made available for more new applications and becomes more competitive on existing processes.

A salient part of the arc furnace is arc-furnace control. The arc has a peculiar, so-called negative, characteristic. It is extremely unstable and tends to destroy itself with increasing rapidity. Its character may be related to a fragile glass block balancing upon a pinpoint. The slightest disturbance will start it to fall to destruction with increasing moments acting upon it to do so.

Maximum efficiency from the arc is obtained when the balanced condition is maintained with the least deviation. Obviously, some counteracting means must be employed to detect when the arc is off balance, which way it is off balance, and proceed to right it without pushing it over in the other direction. All this must be done almost instantaneously.

First means employed to detect the off-balance and correct it is the arc furnace control. Second is added circuit impedance which tends to hold up the arc (or block) until the control responds and moves to take over. The slower the control may be to respond and act, the more impedance must be added to the system to keep the arc in existence and in production. The slower the control, the farther the arc will waiver from its highest point of efficiency. The more the impedance in the circuit, the less energy will reach the arc. Obviously, a control is required that responds and acts instantaneously so that the least amount of added impedance would be required.

New Approach

A new fundamentally different control has been developed as shown in *Fig.* 1. It is a hydraulic differential energized directly from the furnace bus. It eliminates special differential field rotary generators. Electrode motors are driven directly from the furnace bus with no time lag. They draw energy from the bus, which is inversely proportional to the energy of the arc—not just any current and any voltage. It takes the right combination of these two to make the desired energy (heat) in the furnace. This control controls that combination.

Here is how the new control works. Motor M_2 is connected directly to pump P_2 which pumps liquid from the tank T at a constant rate to the cylinder C_c. Motor M_1 is connected directly to pump P_1 and it pumps the liquid away from the cylinder C_c, returning it to the tank T. When the motors are running at the same speed, pump P_1 returns all the output of pump P_2 and the electrode does not move.

When motor M_1 slows down or speeds up, the difference in the output of the pumps either raises or lowers the electrode. Now then, the motor M_1 speeds up or slows down according to the amount the arc is off balance. That is all there is to it.

Both pumps are metering pumps. Pump P_2, doing all the work, is running at constant speed. Pump P_1 acts only as a metering valve, since the pressure across its ports is balanced. It changes speed only in proportion to the arc energy. Metering pumps give volumetric control for precise control of the electrode travel. They do not have valve lands to result in lost motion and loss of control, and do not have the usual port registration difficulties encountered with some valves.

Start-Up

An analysis of *Fig.* 1 will show how the control reacts upon start of operations. All three electrodes, in a three-phase furnace, are set just above but not in contact with the scrap or burden to be melted or heated in the furnace. The control is started and the electrodes are energized. Motor M_1 draws full voltage and energy from the bus and runs at twice the speed of motor M_2. The electrode lowers at full speed until it makes contact with the burden. Either of two things or both happen at this instant de-

pending upon whether the contact is mechanical or electrical or both.

If the burden is corroded or covered with nonconducting material, such as rust, scale, dirt, etc., as in most scrap, only a mechanical contact will be made and motor M_1 will continue to try lowering the electrode. But when the electrode made a mechanical contact with the burden, a part of its weight was shifted off the cylinder and the pressure dropped in the cylinder. Check valve V_4 prevents the pressure in the cylinder from dropping below the air-counterbalancing pressure in the tank. Thus, this valve prevents an excessive shift of weight off the cylinder to the electrode. The electrode, made of graphite or carbon, is quite brittle and cannot safely support the weight of itself, the electrode arm and clamp, heavy copper bus and cable. Valve V_4 permits pump P_1 to run indefinitely at top speed or until the mechanical contact also becomes an electrical contact. Usually this happens without special attention even with exceptionally dirty scrap, especially when electrode voltages are high enough.

When the electrode makes an electrical contact with the burden, the voltage and energy to motor M_1 is shorted through the electrode and motor M_1 slows down. Since motor M_2 is running continuously, the electrode goes up as soon as the speed of motor M_1 passes the speed of motor M_2. If neither of the other two electrodes has made contact with the burden, no arc current will flow. So, this electrode will continue to rise until contact with the burden is just broken. Then the electrode will again lower as before and rise again, continuing the cycle until another electrode makes contact with the burden. At that instant, current will flow through those electrodes. Since the electrodes played lightly on the burden, arcs are instantaneously formed. (This prevents the usual, heavy, short-circuit current flow encountered with the mechanical furnace controls.) Motor M_1, getting energy inversely proportional to the energy of the arc, will increase in speed, slowing the upward travel of the electrode until the maximum arc energy is reached (or some predetermined maximum is reached) when the output of pump P_1 equals the output of pump P_2 and the electrode holds its position at the proper arc length.

Any change of conditions, such as the electrode burning away, the burden melting down, or the main line voltage fluctuating, etc. will cause the control to make correction within 1/20 of a second.

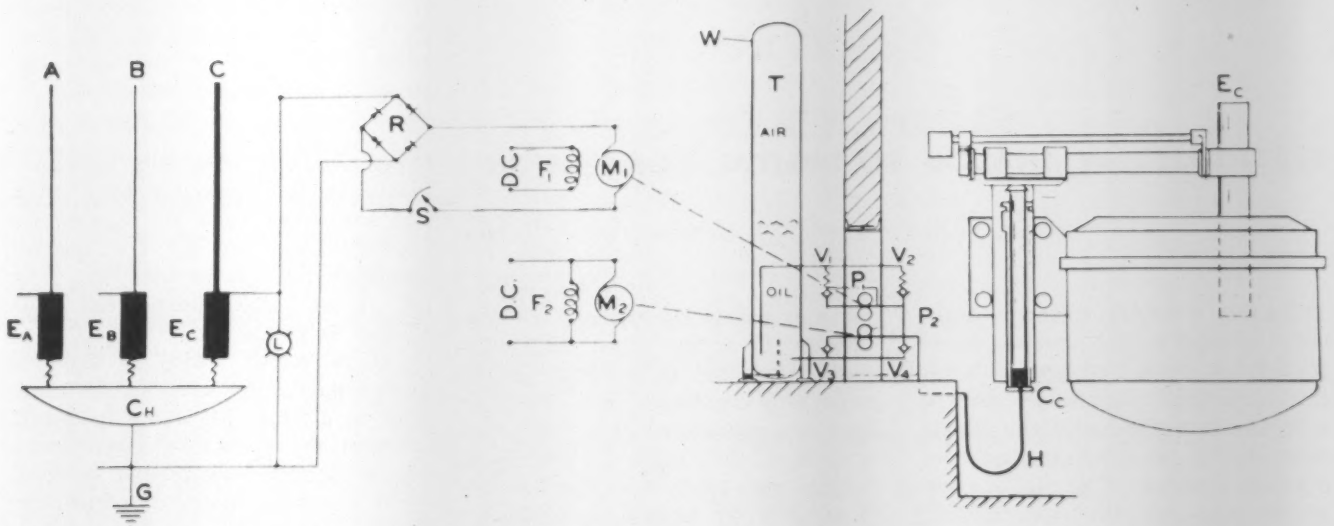
From a paper entitled "A New Way to Control Arc Furnaces" presented at the Association of Iron and Steel Engineers Convention in Cleveland, Sept. 1954.

UP-TO-DATE CONVEYING

O. SVOBODA
E. W. Buschman Co.
Cincinnati, O.

AUTOMATIC OPERATIONS have been developed for a number of reasons; some because the volume would permit a steady flow and warrant the expenditure, some for safety reasons, and some because the workers could not stand the atmospheric conditions of heat, fumes, etc. The most important reason was cost. We all know that every time you touch a product, whether it is with tools, hands or machinery of any type, you add cost.

While large plants making a single product throughout the year have an excellent opportunity to justify the cost of large-scale automation, many smaller plants operating on job shop batch handling



A, B, C — A, B, C phase buses from transformer
E_A E_B E_C — Electrodes.
C_H — Burden in furnace.
G — Ground.
L — Light on operator's panel.

R — Rectifier.
S — Electrode current adjusting rheostat.
D.C. — Direct current supply.
M_1, M_2 — Electrode motors.
F_1, F_2 — Fields.

W — Air supply.
T — Air-oil tank.
V_1, V_2, V_3, V_4 — Valve cluster.
P_1, P_2 — Electrode pumps.
H — Anchor coupling hose.
C_C — Cylinder.

*Patented by Whiting Corp., Harvey, Ill.

Fig. 1—Arc-furnace control system utilizing hydraulic differential and two electrode motors. Elimination of troublesome components such as special generators solved maintenance and time lag problems, simplified circuit complications, and made unnecessary secondary current transformers

of several products will also be able to justify more conservative automation of their plants.

Where parts requiring the same operation vary in size, elements on the indexing and feeding conveyors can be quickly changed. Where different operations are performed, extra machine tools will either be moved into the line, or will be standbys, used on one item, and idle when another item is processed. Job shop operation will permit automatic dispatching from one operation to another that will be flexible enough to accommodate a variety of products, with no change to the conveying system.

Case Histories

We have built conveyors to incorporate lift trucks to perform a stacking operation. A fork truck automatically moves through a cycle to stack packages three high, delivered by a conveyor, then to be taken away to storage or shipping by a power truck, or by additional conveyors to deliver the three tier load to a more convenient location for further handling by other means of truck stacking, cranes, or others.

A new conveyor, developed in the last few years, now handles bottles vertically through a driven spiral in either direction at speeds up to 400 bottles per minute. This same unit can very easily handle mechanical items in the same manner.

Another new development that will have many applications, basically in dipping and finishing, is a cable trolley conveyor which permits the rotating of parts through a vertical circle of 360 deg or more, while being moved horizontally forward. This will shorten dip tanks and eliminate sags and drips when a single heavy coating is being applied because while swinging through a vertical circle the carrier can be rotated, giving a three-directional movement to the parts while passing through drying stages, etc.

We have installed many conveyors to automatically pick up parts or packages at one location and automatically discharge them at various locations, or transfer them to other conveyors more practical for successive operations to be performed. Sorting operations are being performed by conveyors, depositing each item at a different location.

Plans are now being drawn for manufacturer making a complex item, basically of sheet steel, to feed bundled or coiled sheet into one end of the department, and all feeding, blanking, drawing, forming, assembling, spot welding, finishing, packaging, labeling, and palletizing, will be accomplished by mechanical means. The product will not be touched by human hands throughout the entire manufacture.

This will not eliminate jobs, as it will be necessary to have operators of higher skill attend to these automatic operations, to change the tools when they must be ground, to replace broken drill taps, and to eliminate jams that will occasionally happen because some part "just had to get out of line."

As a brief summary, we know the future application of conveyors continues to increase both in duplication of the past and in new applications not previously considered. Modifications of present conveyors and some new types will be developed to meet future economics. Conveyors will be used in greater numbers in more flexible combinations with other types of material handling equipment to meet the demands of more production, lower cost, better quality, to satisfy our continued high living standards.

From a paper entitled "The Future of Conveyor Equipment" presented before the Materials Handling Institute Inc. at Skytop, Pa., Sept. 1954.

VERSATILITY IN ANALOG TO DIGITAL CONVERSION

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National Ordnance Laboratory
Corona, Cal.

STEADY TREND towards automatic control in the process industries is expected by many to burst into new and surprising growth with the introduction of the digital computer as the guiding hand over a whole process. The digital computer with all its computation, communication, and manipulation properties can provide the fast, versatile, adaptable, and flexible control which is needed to co-ordinate the many individual activities essential to a process. It can be programmed, and more important, it can be given a criterion of performance and thus modify its program to achieve this performance by appraising the results as the process is under way. Not only does it promise to eliminate much expensive equipment now used by human operators, but it also promises to control processes which are much too fast to be controlled by human operators.

An important part of systems utilizing digital computers are the devices which provide communication between the process and the computer, the analog to digital converter. The parameters of the process—pressure, flow, temperature, angular position, pH, etc.—must be translated to numbers the computer can understand. Once these numbers have been manipulated in the computer they must be converted back to parameters suitable for use by the control mechanisms. It is with the first of these conversions that this paper is concerned.

It is worth while to examine some particular schemes for analog to digital conversion in detail. Several examples have been chosen to show the mechanisms involved and the wide range of characteristics obtainable.

Direct Counting

The measurement of short time intervals to a high degree of accuracy by direct counting techniques combines the newly developed electrical pulse counters

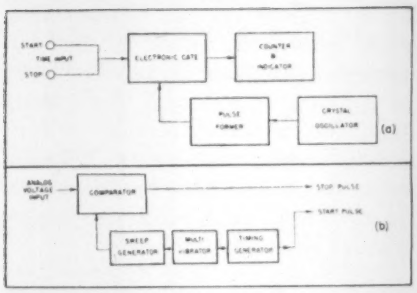

Fig. 1—Class 1, direct counting converter. (a) Time interval measurement, (b) analog transformation of voltage to a time interval

with the stability and accuracy of the quartz crystal. A block diagram of the scheme used is shown in *Fig.* 1a. The functional parts of such an instrument include a very stable and accurate crystal oscillator, a pulse former and amplifier, an electronic gate, and an electronic counter. The oscillator feeds the pulse generator which supplies accurately timed pulses to the gate. The interval of time to be measured must appear in the form of electrical pulses which will open and close the gate at the beginning and end of the time interval.

Timing pulses then flow through the gate during this interval and are counted and indicated by means of a glowing neon bulb in each of several decades. With a 100 kilocycle crystal, the unit of time is 10 microseconds. Five decades allow time intervals up to one second to be measured to a precision of ±10 microseconds. Printers are available for transferring the number in the counter to a roll or sheet of paper.

It is quite obvious that such an instrument might also be used for frequency measurements by substituting an unknown frequency for the crystal oscillator, and providing an accurately known time interval to operate the gate. Instruments of this type have been brought to a high state of development by a number of organizations.

A recent development in this field is the substitution of transistors for the vacuum tubes. Such devices are not yet commercially available.

The fact that such devices have reached a high level of development often makes it advantageous to use them for measurements of

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parameters other than time or frequency, by introducing an analog transformation. Most parameters can be converted to a voltage using transducers. These voltages can then be transformed into a time interval using the scheme shown on *Fig.* 1b. Here a pulse whose width is proportional to the voltage being measured is generated by a linear sweep circuit. When the sweep voltage is equal to the unknown voltage, the pulse is terminated. The width of the pulse can then be measured with the counter.

The parameter can also be transformed into a frequency which again is easily measured. Several devices are available for such transformations. Among these are the vibrating string transducers useful for pressure and displacement measurements. It is also common practice in many FM telemetering systems to transform voltage to frequency by using voltage controlled oscillators.

Subtraction Type

In classification of converter systems, one class of converters may be illustrated by the example of a chemist's balance. The chief characteristic of this device and of others of this class is that they contain provisions for comparing known values with the unknown, discarding those that are larger, and accepting and totaling those that are smaller. They resemble servo systems in that they have an error sensing device, a forward circuit, a feedback circuit, an input, and an output. The most economical measuring procedure is to start the comparison with the highest order digit and progress in turn to the lowest order digit. This is done in some of the devices. In others, the comparison is done unit by unit until equality is reached.

As an example, consider a pulse code modulation converter designed to operate at a sampling rate of 8,000 samples a second, whose block diagram is shown on *Fig.* 2a. The analog input is an audio voltage. It is sampled in the sampler under control of the timing pip generator after which the sample is placed on a capacitor in the storage circuit. It is compared with a reference voltage of 16 units. If it exceeds this reference voltage, a positive pedestal voltage is obtained, which is amplified, limited and applied to the pedestal modulator.

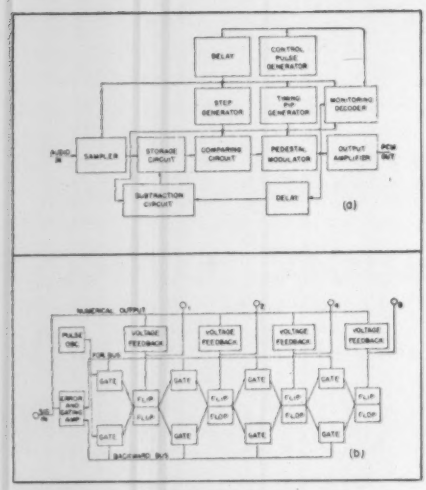

Fig. 2—Class 2, subtraction type converters. (a) Pulse code modulation converter, (b) binary quantizer

This modulator acts as a gate from the timing pip generator. If the timing pulse and the pedestal voltage are applied simultaneously to the pedestal modulator, a pulse appears in the output. This is the first pulse of the code group and is fed to the line after suitable treatment. It is also fed back through a delay circuit to a subtraction circuit, where a charge is substracted from the storage capacitor corresponding to 16 units. The charge remaining on the condenser is then compared to a reference voltage of eight units and the process repeated.

This continues until the charge remaining on the condenser has been compared with a charge of one unit, and thus all the code units are completed. If the magnitude of the charge on the condenser is less than a reference voltage, no pulse will be produced and no charge will be subtracted from the condenser. The next digit value is then examined.

Binary Quantizer

Another quite different example is shown in *Fig.* 2b. Instead of operating on discrete samples like the previous one described, it operates continuously, following the input voltage up and down. This does not mean that it has an infinite sampling rate, however. It consists of an error and gating amplifier, a binary counter of four stages with two gates between each stage, a voltage feedback network from each counter stage, and a pulse oscillator.

The operation is as follows: Suppose that the counter is initially at zero and a voltage is applied to the input. With all counters at zero, no voltage will be fed back, and an error signal will open the gates on the forward bus. Pulses from the oscillator will pass through the forward gates and be registered on the counter. Each stage of the counter produces an analog voltage proportional to the digit value of the counter when the stage is fired. These are summed and fed back to the error and gating amplifier.

Counting proceeds until the analog voltage produced by the counter is equal to the input voltage, producing no error signal. If the input voltage then changes, an error signal is produced which actuates either the forward or backward gates, admitting the oscillator pulses which drive the counter in the proper direction to reduce the error to zero. The state of the counter may be fed to some high speed readout device.

Scale Comparison

Converters based on comparison of amplitude against an established scale have been used to digitize voltage, angular position, and linear displacement. This group contains both very simple and very elaborate devices.

A number of manufacturers make use of mechanical commutators for digitizing shaft positions. The basic idea for the decimal system is shown on *Fig.* 3a. Each commutator contains ten bars which are contacted by a brush rotating on a shaft. Several commutators may be used to obtain additional digits. In such cases, the shafts carrying the brushes are ganged together through 10:1 gear reductions to secure the proper relation among the digits.

Basically this idea is simple, but complications arise because the

brushes are of finite size and therefore may cause contact of two bars at one time, thus producing ambiguity in the result. Many ingenious schemes are used to overcome this difficulty. In one device a relay control system is interposed between the commutator bars and the indicator lamps and readout device, whose purpose is to eliminate this uncertainty by giving preference to the smaller digit of the two contacted until the brush has completely left this contact.

Other devices rely on mechanical positioning arrangements which act either continually or during the readout to assure that no ambiguity takes place. These provide quantizing or toggle action effects.

Converters of this type may be incorporated with equipment for digitizing other parameters than shaft position. They may be connected directly to instrument shafts or to the shaft of a servo motor in a balancing bridge arrangement. They are often used on film readers where a pointer is manually moved from a reference position to a trace on the film. The pointer is connected to the converter by appropriate mechanical linkages and the trace on the film is thus easily digitized. The commutator can carry sufficient current to operate electric typewriters and card and tape punches.

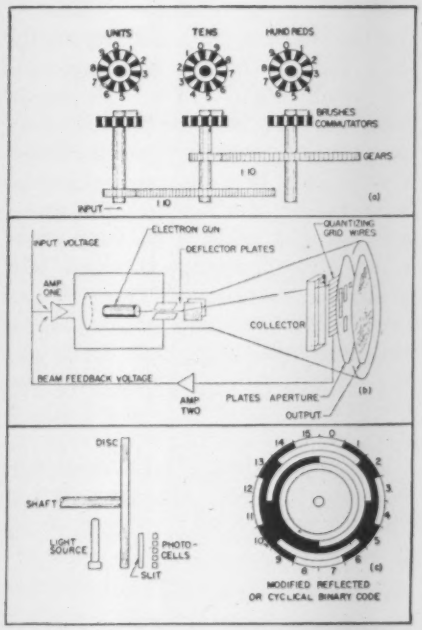

Fig. 3—Class 3, converters using comparison against an established scale. (a) Commutation angular position converter, (b) pulse code modulation coding tube, (c) binary coded disk

An entirely different approach is seen in the pulse code modulation tube which permits digitizing audio frequency voltages at a sampling rate of 8,000 samples per second and expresses the result in a 7-digit binary code. A simplified sketch of the tube is shown in *Fig.* 3b. It resembles a cathode ray tube in most respects but has in addition, a collector, quantizing grid wires, a mask containing binary representations of numbers from 0 to 127, and a metal collector plate.

Broadly speaking, the voltage to be digitized is placed on a pair of deflection plates deflects the beam across the mask, and the pulses of current produced on the output plate represent the binary

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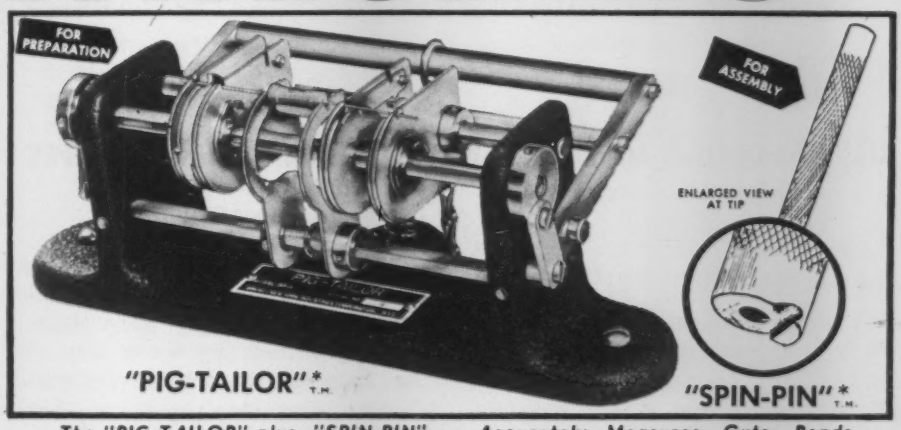

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number corresponding to the input voltage. The beam is quantized to lie in only a discrete position by the action of the quantizing grid wires. Feedback from these wires to the vertical amplifier accomplishes this result.

A different version of this tube has also been described. The need for quantizing wires has been eliminated by coding the mask in the reflected binary code which is self-quantizing. The pencil shaped electron beam is replaced by a fan shaped beam which gives parallel rather than serial operation. A separate target plate is associated with each opening in the mask. The unknown voltage shifts the fan shaped beam along the mask.

Another ingenious and relatively simple device is the binary coded disk which converts shaft position to digital form by the interpretation of binary numbers written radially on the disk. A diagram of this scheme is shown in *Fig.* 3c. The disk is divided into a sufficient number of sectors to give the desired precision. (One with 16 sectors is used in the illustration.)

Each sector representing a quantum of angular position is coded radially in opaque and clear areas corresponding to the proper reflected binary number. Facing this coded area is a narrow radial slit. Behind the slit is a photocell for each digit. The photocells recognize the zero or one properties of the code. The modified binary code has the property that only one of the digits of the number changes from 0 to 1 or from 1 to 0 in passing through one quantum distance. This means that when the slit is straddling two numbers, only one digit will be uncertain and therefore the resulting number is in error by at most one quantum distance.

A similar device for linear displacements using phototransistors and transistors has recently been reported.

Future Developments

Most development effort so far has been directed towards devices which accept voltage, angular position, and the combination of frequency and time as inputs. These are some, but obviously not a complete set, of the parameters of process control. However, available transducers which are accurate, convenient, and reliable make possible the transformation of most parameters of process control into these three. In addition, converters have been built for digitizing linear position and pressure directly.

Most of the activity has been in development. Mass production has been largely confined to the electronic counters and time interval meters. Smaller production items include those used in data reduction. Some manufacturers supply devices on a custom basis only, tailored to suit particular applications. The field is relatively new, and neither the requirements nor the devices have been specified to the point where standardization is possible. As system studies on processes proceed and as the role of the digital computer in these processes becomes better understood, the requirements for the connecting link—the analog to digital converter—can be spelled out in greater detail. They can then become a standardized, inexpensive, compact, and reliable part of a control system.

From a paper entitled "Analog to Digital Converters" presented at the International Instrument Congress and Exposition of the Instrument Society of America in Philadelphia, Sept. 1954.

ULTRASONICS IN INDUSTRIAL CLEANING PROCESSES

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Detroit, Mich.

ULTRASONICS in the fields of industrial application has been unduly exaggerated. Any proposed application, or any scientist's invention or dream which was associated with ultrasonics has secured over-optimistic publicity and encouraged some unwise attempts to utilize ultrasonic energy. Wide areas of research still remain, looking to development of practical and useful ultrasonic processes.

Ultrasonic industrial cleaning process is one such process that has successfully emerged out of several years of applied research. Practical, efficient ultrasonic cleaning units are now available, and in use on high-production lines. Ultrasonic energy can be produced practically for cleaning applications by using any of the transducing methods: piezoelectric, magnetostrictive or electrostrictive. It is not the purpose of this paper to give a detailed story of all the possible forms of ultrasonic transducers. All three above methods of transducing electrical energy to sound energy have been used to some degree in cleaning processes.

The method which seems best for continuous production line cleaning appears to be the electrostrictive, with perhaps the magnetostrictive method running second. This classification is made advisedly, since the technique is very new and little is known about how to use ultrasonic power to its greatest advantage. The electrostrictive method using barium titanate is the leading technique at the present time.

Reason that the electrostrictive method using barium titanate as a transducer appears to have merit over other types of transducing methods in the application under discussion is that barium titanate is a ceramic and can be cast into various shapes so that the sound energy can be focused on a particular area. After casting and firing, the ceramic can be polarized to give it electrostrictive proper-

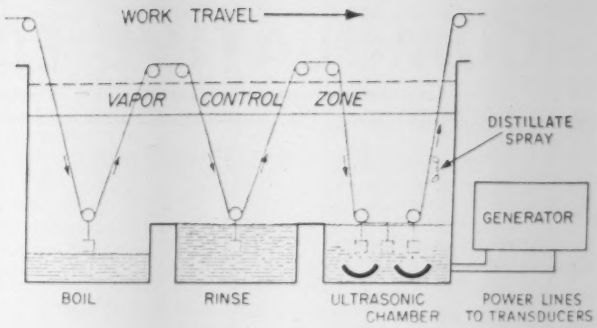

Fig. 1—Typical three-stage degreaser with an ultrasonic chamber. Transducers are loaded at four watts per square centimeter and solvent in the ultrasonic chamber is kept at approximately 140F

ties. This means that the total energy from the surface of a transducer can be utilized after it is concentrated to a high energy density. The impedance is quite low, which allows the unit to operate at comparatively low voltages.

For instance, to irradiate an aqueous solution with an ultrasonic intensity of 1 watt per square centimeter and at a frequency of 100 kc, the voltage necessary for a transducer made of quartz crystals would be 10,000 volts, whereas the same result could be achieved by a ceramic transducer with only 100 volts. This low voltage allows for simple connections to remotely located radio frequency generators. The transducer may also be placed directly in nonpolar cleaning fluids such as trichloroethylene without short circuiting it, eliminating the necessity of using inefficient diaphragms or acoustic windows.

Applied to Industrial Cleaning

Violent agitation occurs in a cleaning medium when an uninsulated barium titanate trough type transducer is placed in the nonpolar solution (trichloroethylene) and activated by a radio frequency generator matched to the resonant frequency of the transducer.

To obtain the best results and maximum efficiency from ultrasonic energy, the technique must be employed as a tool in conjunction with a well designed cleaning process. Where present methods are not adequate, the ultrasonic technique is employed only as an additional process to remove the final traces of objectionable soil still remaining. In other words, the ultrasonic technique should be used as an additional process to attain perfect cleaning. The transducers then operate in a separate cleaning chamber in which the ultrasonic energy will remove the final traces of residue after the gross soil has been removed. The last traces of soil may be removed from the liquid by filtration or other means so that the workpiece being cleaned may be withdrawn from the liquid without fear of redeposition of soil. This type of application lends itself very nicely to the solvent degreasing process.

Degreasing Process

Diagrammatically shown in *Fig.* 1 is a solvent degreasing process to which an ultrasonic chamber has been added. The solvent degreaser, as such, may be operated by utilizing one of the popular solvent degreasing cycles, such as vapor-spray-rinse, immersion-vapor-rinse, etc. The gross soil is removed during this regular cycle of operation and the final traces of residue are removed as the workpiece goes through the ultrasonic chamber. The workpiece is always immersed in the liquid in the ultrasonic chamber. The distillate from the boil chamber is condensed at the vapor control zone and is pumped continuously through spray nozzles which flood the workpiece as it leaves the ultrasonic chamber.

This distillate spray drops into the ultrasonic chamber and continuously flows into the rinse which continuously overflows to the boil chamber. The recycled distillate is an aid in keeping the ultrasonic chamber free from soil. In addition, the liquid in the ultrasonic chamber is continuously filtered at a high rate (not shown) which reduces the soil suspended in the ultrasonic chamber.

If necessary, separate distillation equipment is placed in the system to force additional clean distillate to the ultrasonic chamber. The temperature of the solvent in the ultrasonic chamber is kept at approximately 140F, which seems to be optimum for cleaning and is sufficiently low to prevent the transducers from reaching the Curie temperature (248F), at which temperature they would depolarize. The transducers are loaded at four watts per square centimeter.

Other models of this same type unit are equipped with monorail through type conveyors rather than the cross rod conveyor. They may be adapted to almost any type of material handling.

Best Application

In summary, it can be said that the ultrasonic technique can, and is, being used as a powerful tool in the field of industrial cleaning; that it is best employed as the last stage of a well designed cleaning process; that it is adaptable to the process of solvent degreasing using chlorinated hydrocarbon solvents; that barium titanate transducers are far more adaptable than other types at the present time; that the ultrasonic technique can, and is, being adapted to production line cleaning; and lastly, that the best cleaning results in the history of the industry are being obtained by ultrasonics in conjunction with solvent degreasing.

From a paper entitled "Ultrasonic Techniques in Industrial Cleaning" presented at the Annual Meeting of the American Society of Tool Engineers in Philadelphia, April 1954.

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AUTOMATION

PATENTS

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Communications

FREQUENCY AND PULSE TIME MODULATION TELEMETRIC SYSTEM

Receiving station for producing a record of the frequency of a received signal wave; transmitting station has oscillator for generating a signal wave, means for modulating the frequency of the oscillator in accordance with a first reading that is continuous and variable, means for shifting the frequency of the oscillator an arbitrary amount in accordance with a second reading that is discontinuous and has only one value, means for transmitting the signal wave. Patent 2,676,314 by Marcel Wallace, assigned to Panoramic Laboratories.

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Controls

AUTOMATIC FREQUENCY CONTROL SYSTEM FOR OSCILLATORS

Frequency of the wave produced by a controlled oscillator is compared in a phase detector with the frequency of a reference oscillation to produce a control voltage having direct and alternating voltage components, depending on the displacement between the wave and the reference oscillation. Patent 2,676,262 by Eduard Herman Hugenholtz, assigned to Hartford National Bank and Trust Co.

SHAFT POSITIONING MECHANISM FOR BINARY CODE OPERATION

For controlling position of a shaft, uses plurality of relays which control contact arms; motor control relay and driving means connected to power supply. Output shaft of driving means has toothed stop wheel and four wafer switches with one, two, four, and eight peripheral projections each respectively. Patent 2,676,289 by Arthur H. Wulfsberg and Horst M. Schweighofer, assigned to Collins Radio Co.

AIR CONTROL RELAY WITH MULTIPLE RESPONSES

Body casing has stationary and movable partition walls forming separate input, output, third and fourth chambers. Means for maintaining input pressure in the input chamber which varies in accordance with changes in a controlled variable. Valve arrangements maintain an output pressure in the output chamber dependent on the pressure in all of said chambers, and maintain in third and fourth chambers each, a pressure in predetermined relation to the output pressure and which vary in a predetermined manner upon change of output pressure. Patent 2,675,819 by Donald P. Eckman and Joseph G. Horn, assigned to Minneapolis Honeywell Regulator Co.

• • •

Data Processing

CARD FEEDING DEVICE

Carriage for a machine for perforating data designations in the columns of a record card has stop for registering the leading edge and a pusher co-operable with the trailing edge linked with a positive retracting means to make clearance for receiving the next card upon the return movement of the carriage. Patent 2,675,231 by Charles R. Doty, assigned to International Business Machines Corp.

AUTOMATIC DEVICE FOR SUPERVISING THE REGULAR TRANSPORTATION OF CARDS IN A CARD-CONTROLLED BUSINESS MACHINE

Detects superposition or overlapping of one card over the other, also detects lateral deviation of cards from the path of travel; arranged to stop feeding of the cards when the detector tubes are actuated. Patent 2,675,233 by Gerben J. Keulen, Adrianus Kool, and Hendrik A. Cival, assigned to Nederlandse Boekhoud-en Statistiekmachine-Maatschappij Bullatec N. V., Netherlands.

• • •

Handling

APPARATUS FOR CONVEYING PIPE THROUGH ELECTROLYTE

Movable arms are swingably suspended from endless tracks at each side of an electroplating tank and driven by conveyors. Separate conveyor brings pipe lengths to tank station where arm loading plunger mechanisms press fingers of oppositely aligned arms into ends of the pipe which is thereby transported through the bath. Cams spread apart the fingers and the arms return to reload. Patent 2,675,813 by Frank J. Kennedy, assigned to National Electric Products Corp.

SORTING DEVICE

Articles of different sizes are fed from conveyor with concave rolls for aligning the articles before dropping them individually past a photoelectric means which produces a current controlled in proportion to article size. Each item is allocated to one of a plurality of duct members connecting storage hoppers and closure gates which are arranged in gable fashion and controlled by individual motors having different starting torques. Patent 2,675,917 by John B. Powers, assigned to University of California.

• • •

Machine Tools

MACHINE FOR FORMING SCREW DRIVER BITS OF THE FLUTED TYPE

Four milling cutter units each mounted on plates arranged in angular and equally spaced relation to one another reciprocate into cutting position in unison with the movement of the screw driver shank carriage, such as to feed the cutters into the shank and return the carriage and plates to inoperative position. Patent 2,675,744 by John N. Petre, assigned to XceLite Inc.

• • •

Machines

SPRAY COATING APPARATUS

Including a conveyor having a plurality of equally spaced article supports, a spraying station in which a plurality of spray guns are positioned to coat surfaces of articles on said supports, a device adjacent the conveyor detecting by contact the presence of an article on each support, and pneumatic control circuits connecting the detection device and the spray guns. Patent 2,675,778 by Donald J. Peeps, assigned to DeVilbiss Co.

BOWLING PIN SETTER

Two frames movable vertically are supported above the alley pin deck. One has setting means comprising of tubes extending downwardly from the frame in pin setting positions. The other has pickup bars adjacent each opening and closure devices operable to engage the head end of pins standing on the alley pin deck. Patent 2,676,016 by Jack Van Horn Whipple and Albert L. Odmark, assigned to Brunswick-Balke-Collender Co.

AUTOMATIC VEHICLE COUNTER

Horizontally elongated casing in an upright anchored relation to a roadbed having a lane to cause the wheels at one side of a vehicle to move along a path closely parallel to the casing and operate a lever of the mechanism causing it to swing in; this action causing, through the linkage, a second lever to swing out into the path of the wheel; when this lever is struck by the wheel it swings back in, operating the counter and causing the first lever to swing out again into its original position. Patent 2,675,964 by Mischa N. Berezny.

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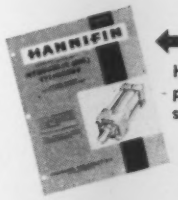

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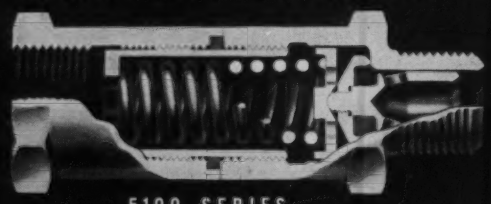

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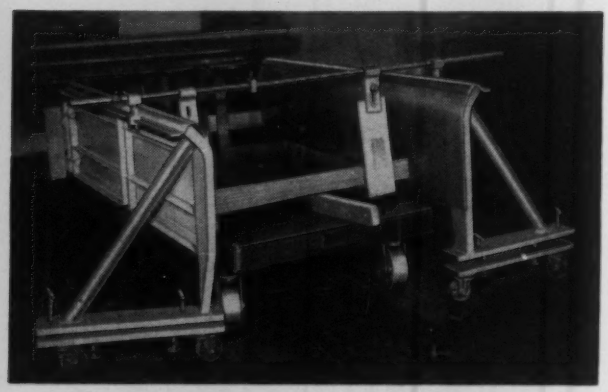

ONE TYPE OF STACKER BACK OF ROLL

Automatically

STACK PARTS FROM

SHEARS — ROLLS — PRESSES — WELDERS

Hamilton *Inc.*

Automation

HAMILTON, OHIO

AUTOMATION

NEW BOOKS

DIELECTRICS AND WAVES

By Arthur R. von Hippel, professor of electrophysics and director, Laboratory for Insulation Research, Massachusetts Institute of Technology; 273 pages, 8¼ by 11¼-inches, clothbound, published by John Wiley & Sons Inc., New York; available from AUTOMATION, $16.00 *postpaid.*

Data in this volume show that dielectric analysis has gone far enough to permit the beginnings of dielectric synthesis, in which the properties of materials are tailored to order. Work develops in two parts, the macroscopic and molecular approach to an understanding of polarization, magnetization, and conduction phenomena.

•

MODERN PHYSICS FOR THE ENGINEER

By Louis N. Ridenour, vice president, International Telemeter Corp.; visiting professor of engineering, University of California; 490 pages, 6 by 9¼-inches, clothbound, published by McGraw-Hill, New York; available from AUTOMATION, $7.50 *postpaid.*

Volume comprises a collection of lectures delivered to an extension course at the University of California (1952-1953). It provides reader who has a basic technical background with a brief account of some of the more interesting developments in the fundamental science underlying all engineering. Section dealing with modern electronics is particularly valuable for those seeking background information on this subject.

•

MACHINE DESIGN

By Vladimir L. Maleev, professor emeritus of mechanical engineering, Oklahoma Agricultural and Mechanical College, and James B. Hartman, head, department of mechanical engineering, Lehigh University; 690 pages, 6 by 9½-inches, clothbound; published by International Textbook Co., Scranton, Pa.; available from AUTOMATION, $8.50 *postpaid.*

This third edition includes data on the development of unified screw-thread system; new fastening devices; involute splines; and new approaches to gear design.

Materials such as ductile iron and various aluminum alloys are also discussed.

New sections have been introduced to reflect increasing use of more thorough stress analysis, including statically indeterminate structures, curved beams and shear in beams. More emphasis has been assigned to the importance of understanding manufacturing processes by adding two chapters and by grouping all of the chapters on manufacturing in a new Part II.

Government Publications

Transistor Circuitry For IF and Audio Amplifiers. *Report PB 114233 by Zenith Radio Corp. for Army Signal Corps; 41 pages; available from Library of Congress, Publication Board Project, Washington 25, D. C.; $2.75 per microfilm; $6.50 per photocopy.*

Research was done for Army Signal Corps in hopes of hastening day when practical, low-cost transistors can replace bulky vacuum tubes in radio receivers. This final report details studies of transistor circuitry in single and double turned intermediate frequency amplifier circuits and periodic audio-amplifier circuits. Included are results of tests with a 2 mc. transistor I. F. amplifier with a bandpass filter to provide the selectivity required in military FM receivers. A four-stage point contact transistor amplifier is used, one stage preceding and three stages following the filter.

•

Synthetic Mica: A Critical Examination of the Literature. *Report PB 111428 by Office of Naval Research; 74 pages; available from U. S. Department of Commerce, Office of Technical Research, Washington 25, D. C.;* $2.00.

One hundred years of research into the development of a synthetic mica, or mica substitute, is described in this report prepared by Pennsylvania State College for the Office of Naval Research. With the rapid expansion of this nation's electronic and electrical industries, and with our dependency upon a single nation for the bulk of our supplies of natural sheet mica, the need for such a material has become especially acute. This report collects and collates findings of investigators over the past century and details present technology for both "dry" and hydrothermal synthesis.

Industrial Publication

THE AUTOMATIC OFFICE

46 pages, 8½ by 11 inches, paperbound; available from Alden Systems Co., Alden Research Center, Westboro, Mass. $5.00.

Purpose of report is to review developments in electronic computers and to evaluate them in light of their usefulness to the businessman. Topics discussed include: development of the modern computer, how it works, and some of the problems which remain to be solved before computers can be widely applied to business.

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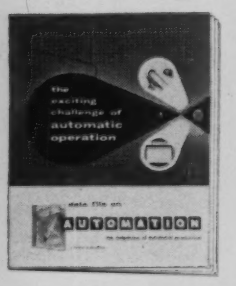

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20	Food and Kindred Products	1340	6	210	203	917	4
21	Tobacco Manufacturers	62		10	9	43	
22	Textile Mill Products	965		203	97	664	1
24	Lumber and Wood Products	403		112	66	225	
25	Furniture and Fixtures	181		44	42	95	
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28	Chemicals & Allied Products	1348	9	173	281	884	1
29	Petroleum & Coal Products	427		27	68	332	
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Today's radically changing economic conditions resulting in demands for still lower unit costs have been responsible for the accelerated pace in the design of fully "AUTOMATED" automatic machinery.

McKay has for many years been working in close cooperation with the major auto producers, the steel industry and fabricating plants in the development of Automated Machines that automatically take over sequential operations and combine operational functions in preparing and handling raw materials as well as processing and handling finished products.

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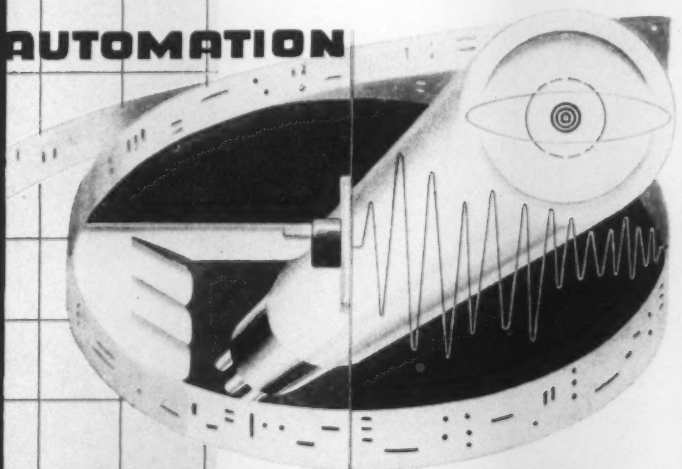
AUTOMATION



IN ACTION

● The illustration here was designed to exemplify "Automation in Action." It is a composite of a few of the more familiar symbols created by artists to signify this new era of automation. It will be used hereafter to designate truly "automated" machines designed and built by McKay.

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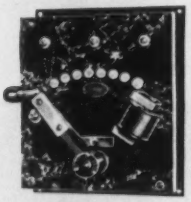

The "Kitty Hawk" of Automation

The very first automatic feature in motor control was the no-voltage release in the Cutler-Hammer Bulletin 10 Starter of 1892. The starter handle was held in the "on" position by an electromagnet and returned automatically to the "off" position whenever the power supply failed. This protected men at machines from sudden unexpected restarting, motors against burn-out due to the inrush of uncontrolled current.

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C·H